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DISPERSION OF MUSCA DOMESTICA LINNÆUS UNDER CITY CONDITIONS IN MONTANA

Contribution from the Laboratory of the Montana State Board of Entomology, State College, Bozeman, Mont.

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Introduction

The Montana State Board of Entomology has been conducting an intensive study of certain conditions which directly or indirectly affect the question of fly control in Montana. During the season of 1914 data were collected to determine what species of flies are found in cities and towns, their comparative abundance, their seasonal abundance, what conditions favor their abundance and what general and local economic conditions must be considered in outlining control work. The detailed results are as yet unpublished. During the season of 1915 it was found advisable in continuing the work to devote considerable attention to the dispersion of the house-fly under city conditions. Miles City was selected as eminently suited for such work because of three facts; namely, the great abundance of flies, the representative size of the city and the lack of efficient control measures. The dispersion investigation and its results are discussed in this paper.

Review of Previous Dispersion Experiments

The importance of the radius of fly dispersion with relation to house-fly control propaganda and the spread of disease organisms by this insect has been responsible for several attempts to accumulate experimental evidence. Arnold (1907)[1] in Manchester, England, liberated 300 flies marked with a spot of white enamel and recovered five at distances of 30 to 190 yards. Copeman, Howlett and Merriam (1911)[2] conducted experiments at Postwick, England. Flies marked

with colored chalk (by shaking in a bag) and liberated at refuse accumulations about one-half mile from the village church were afterward recovered in the village. In fact they were able to recapture marked flies at 1,700 yards and found that distances of 800 to 1,000 yards were often traversed and that flies would travel 800 yards in thirty-five to forty-five minutes. Howard (1911)[3] notes experiments by Hine in which 350 flies were marked with gold enamel and recovered during three days at distances of 600 to 1,200 yards. Hine is of the opinion "that the distance flies may travel to reach dwellings is controlled by circumstances. Almost any reasonable distance may be covered by a fly *under compulsion to reach food or shelter. When these are close at hand the insect is not compelled to go far and, consequently, does not do so*" (author's italics). Experiments by Forbes were also recorded. Flies were sprayed with a chemical solution and recovered up to a distance of one-fourth mile. They were identified by another spraying with a solution which gave a blue color to those previously sprayed. Doctor Howard states that "the house-fly will seldom travel very much farther than it has to fly for food and a proper nidus for its eggs, but as a matter of fact, this is difficult to prove." Hewitt (1912)[4] conducted experiments at Ottawa during which 13,600 flies were liberated during a period of nine days. These flies were sprayed with a solution of rosolic acid. After recovery such flies when wetted with a slightly alkaline solution became scarlet. The point of liberation was near an isolation hospital on Porter's Island in the Rideau River. One hundred and seventy-four flies were observed or recovered at from 180 to 700 yards within nine days after the first release. It was found that flies "were usually collected in that portion of the district toward which the *wind had been blowing from the direction of the island, as it was found that the wind was the chief factor in determining the direction of distribution*" (author's italics). Doctor Hewitt further states that "there is no doubt that given the necessary conditions with regard to wind and elevation above the ground, the range would be considerably greater than was actually found in these experiments." Professor C. F. Hodge (1913)[5] records plagues of flies at the cribs of water works situated one and one-fourth, five and six miles respectively out in Lake Erie. He concluded that they had been carried by the wind and had gathered on the cribs as temporary resting places. These observations concerned *Stomoxys* and *Calliphora* as well as the house-fly. Hindle (1914)[6] gives the results of experiments conducted during July, August and September of 1912. Over 25,000 flies were liberated and fifty points established for their recovery. "The results of these experiments point toward the following conclusions: (1) that house-flies tend to travel either against or across the wind; this di-

rection may be directly determined by the action of the wind, or indirectly, owing to the flies being attracted by any odors it may convey from a source of food; (2) that the chief conditions favoring the dispersal of flies are fine weather and a warm temperature; the nature of the locality is another considerable factor, *as in towns flies do not travel so far as in the open country, this probably being due to the food and shelter* (author's italics) afforded by the houses; (3) that under experimental conditions, the height at which flies are liberated and also the time of day, influences the dispersal of the insects, when set free in the afternoon they do not scatter so well as when liberated in the morning; and (4) that, in the experiments made, *the usual maximum flight in localities where houses are numerous seems to be about a quarter of a mile* (author's italics), but in one case a single fly was recovered at a distance of 770 yards; it should be noted, however, that part of this distance was across fen land."*

Mr. J. Zetek (1914)[7] liberated about 5,000 flies stained with an aqueous solution of gentian violet to which a small amount of gum tragacanth had been added at an extensive manure pile 2,500 feet distant from Isthmian Canal Commission Hotel at Ancon, Panama. Seventeen flies were recovered in several screened buildings in Ancon; these were mainly *Musca domestica* Linnæus and *Hermetia illucens* (Linnæus). The writer (1914),[8] while conducting certain investigations for the Montana State Board of Entomology at Laurel, succeeded in tracing flies by placing a thick syrup colored with a red fruit extract at a privy; flies which fed on this were identified when recaptured by the red contents of the intestinal tract which showed very prominently through the ventral membrane of the abdomen. The experiment was continued but three days. Twelve flies were recovered at residences up to a distance of 150 yards and two specimens, one *Musca domestica* Linnæus and one *Fannia scalaris* Fabricius, at a meat market 300 yards distant.

The experiments as outlined above have suggested to the several investigators concerned somewhat different conclusions, both in respect to the radius of dispersion and the factors which control it. The work of Hine, Hewitt, Hindle and Parker have to do with dispersion, wholly or in part, under city or town conditions. Other observations noted concern flight across the open and under more or less rural conditions. Hewitt and Hodge are of the opinion that flies travel with the wind, while Hindle believes his work indicates that the direction of flight is against or across the wind. In partial support of the opinion of the two former writers, we have the observation of

*Quoted from Review of Applied Entomology, Vol. 2, Ser. B., Pt. 2, p. 39, Feb. 1914.

Munson (1901)[9] concerning the typhoid epidemics of 1898 that "where a strong wind constantly blows from the same direction, a fly-borne infection will extend down wind, as this insect always rises and generally moves in the direction of air currents." As is so often the case, it is probable that these two diametrically opposed opinions may be made to harmonize. Concerning flight across open country the evidence presented is entirely in favor of the view that long distance flights are common, especially up to distances of one-fourth to one-half mile and longer distances are indicated by the observations of Copeman, Howlett and Merriam and Hodge. Concerning distance of flight under town and city conditions the evidence presented seems to favor the view that where "food and shelter" are at hand dispersion is confined to within comparatively short distances of the breeding place. Such is the opinion of Hine, Howard, Hewitt and Hindle, though both Hewitt and Howard suggest the possibility of longer flights. Cox, Lewis and Glynn (1912)[10] in discussing the possibility of flies moving from one street or locality in a city to another make the statement that "our observations, however, prove that such migrations from one area to another do not occur to any extent."

The total number of flies used in these several experiments to determine the distance of dispersion would probably total less than 50,000, the work of Hindle accounting for more than one-half. All work done then, and all the conclusions are based on a fewer number of flies than would be expected to be produced during a season at any ordinary center of dispersal, such as a manure pile.

It is fully apparent that these experiments and observations leave much to be desired, especially from the standpoint of conditions in Montana. On the data at hand it can be surmised that flight across open country may be to considerable distances, but no limit of a definite nature is given, if indeed it be possible to establish such. The evidence presented concerning flight under city conditions is even less conclusive; a comparatively short radius of dispersion is indicated and statements of conclusions are more or less definitely qualified, though positive assertions, such as that of Cox, Lewis and Glynn are not lacking. Suggestions as to factors influencing or determining the radius and direction of dispersion are not few, but on the other hand, they are neither convincing nor conclusive. The experiments and results with which this paper deals concern an entire city and the liberation of nearly 400,000 marked flies. This is about eight times the total of all previous investigations combined and more than fifteen times as many as were used in the most extensive of these.

Objects of Investigation

Realizing that in Montana cities and towns, with the possible exception of a few of the larger cities, conditions are quite similar, except as regards the extent of territory covered, it was felt that investigations on dispersion conducted in a city of medium size would lead to results of general application. With this idea in mind the objects of the summer's work may be stated as general and specific, the latter referring to the special problems of the city concerned.

General Objects.—(1) To determine the distance from breeding grounds to which flies may be expected to travel under city conditions and the amount of territory over which they may spread, (2) to determine what factors control dispersion under city conditions.

Specific Objects.—(See Plate 23.) (1) To determine the radius of dispersion from the Laboratory, (2) to determine the radius of dispersion from the Miles City Sales Yards, (3) to determine the radius of dispersion from the City Dump, (4) to determine the radius of dispersion from the Washington School, (5) to determine the factors which controlled this dispersion.

These release points were dictated by local conditions and were so selected as to give an idea of the possible dispersion from breeding grounds variously located with reference to the city as a whole.

Local Conditions

As previously stated, Miles City offered unusually good opportunities for experimental work. The horse sales yards (Pl. 25, fig. 7) just west of the city, probably the largest in the world, furnished a breeding ground of great extent from which flies bred out in many millions. Many partially or entirely uncontrolled breeding places throughout the city added their quota.

The built-up portion of the city is perhaps two square miles in area and may roughly be included within a square one and one-half miles on a side. Thus the size of the city was such that it would permit the application of results to practically all Montana cities and towns and yet not too large to be covered during a season's work.

Regulations dealing with the removal of manure, etc., were in existence, but local conditions prevented their application in a way that would be effective. The City Dump to which refuse was supposed to be carried was scarcely outside the city limits.

Except along the business section of Main street the buildings are, for the most part, well separated. No section would in any way correspond to the congested areas with high buildings and narrow streets found in so many large cities.

The most closely populated portion of the city is that lying between

the Northern Pacific and the Chicago, Milwaukee & St. Paul railroads. The principal business section may be roughly included within a triangle having the Northern Pacific Railroad as its base and Fifth and Pleasant streets as its sides.

In speaking of "fly conditions" at Miles City the writer has used the word "natural." The expression "fly conditions" refers to those conditions, the variability of which affects the existence of the house fly favorably or unfavorably, *e. g.*, presence or absence of breeding materials and their availability, presence or absence of garbage and how it is cared for, etc. The term "natural" means that "fly conditions" are very favorable, both for their spread and multiplication.

Description of Release Points

Laboratory (release point number 1).—The Laboratory was situated about midway on the eastern edge of the city. Directly east there were no houses; to the northeast there were but few south of the railroad, but more beyond it to the north; to the south of the Northern Pacific tracks the houses extend eastward to some distance beyond the street on which the Laboratory was located, but are somewhat scattered; in all other directions the city was well built up. The best residential section was about one-eighth mile to the west. Figure 10 shows the Laboratory as seen from the Northern Pacific tracks with the city in the background.

Flies released at this point had been captured in several Hodge traps set on a table in the rear of the building. Flies were abundant due to garbage and manure piles near by.

Sales Yards (release point number 2).—The Sales Yards (Pl. 25, fig. 7) are located southwest of the central portion of the city and just beyond its limits. In all they cover $44\frac{1}{4}$ acres of which $24\frac{1}{4}$ are in pens. They are both north and south of the tracks of the Northern Pacific railroad. The houses are scattered in the vicinity of the pens to the south and the nearest of these is 300 yards from the pens to the north in which we are most interested. The latter cover nine acres and are the most productive breeding grounds. Except for a few houses in the vicinity of Station 109, the business section of the city along Fifth street (400 to 530 yards) is the portion of the city north of the railroad which is nearest the yards. It is also the most insanitary section. Between this and the release point lies the city park (Pl. 25, fig. 4) and a narrow belt of woodland along the old channel of the Tongue river. Figure 1 was taken looking toward Miles City from the west and shows the locality of the release point, while Pl. 25, fig. 2 was taken from this release point looking directly toward the city. The City Dump release point was about 800 yards north and slight-

ly west. Between it and the Sales Yards lies the old channel of the Tongue river and a considerable wooded area between the old and the present channels.

During favorable conditions flies breed out at these Sales Yards in immense numbers. The flies released here were captured for release at the point designated at Station 168. Pl. 26, fig 11 shows one of the traps in which they were captured. Flies for release at the City Dump and Washington School were also captured here in four Hodge traps.

City Dump (release point number 3).—This is located on the bank of the Tongue river at the tip of a bend in its course. It is several hundred yards west of the west central edge of the city, though there is a group of houses between First and Second streets. Otherwise the nearest section of the city is a negro settlement. Between the Dump and Second street are woods of a rather open character (Pl. 25, fig. 6). Most of the material brought to the Dump was burned, but flies were nevertheless very abundant. In order to reach the city from this point flies would have to traverse the woodland or take a roundabout course up the old Tongue river channel, though even in the latter case it would be necessary to pass through, around, or over woodland of less extent.

Washington School (release point number 4).—This school building and the grounds occupy the city block between Ninth and Tenth streets and Orr and Palmer. It is in the best residential section and quite centrally located, both with relation to the city and the other release points.

Table I Estimated Number of Living, Marked Flies in each Lot Released from each Release Point and Season's Totals

Date	Laboratory	Sales Yards	City Dump	Washington School	Date	Laboratory	Sales Yards	City Dump	Washington School
July 12	129				July 30	2,515	20,000		
13	238				31	1,958	15,000	5,000	5,000
14	997				Aug. 2	2,166	15,000	2,500	2,500
15	740				3	3,582	20,000		
16	1,353				4	2,915	20,000	5,000	5,000
17	820				5	2,892	10,000		
19	853				6	2,365	10,000	5,000	5,000
20	986	640			7	2,820	15,000		
21	1,225	3,000	3,000		9	314		5,000	2,500
22	773	10,000			10		1,000		
23	924	20,000	8,000	4,000	11	123	1,500		
24	1,366	15,000			12		15,000	5,000	5,000
26	1,531	15,000	8,000	8,000	13		1,000		
27	1,912	15,000			14		1,000		
28	2,510	20,000	8,000	8,000	16		5,000		
29	2,230	10,000							
					Totals	40,237	248,140	54,500	45,000
Total flies released									387,877

Establishment of Recapture Stations and Placing of Traps

The most satisfactory results would have been obtained if it had been possible to select a large number of stations and collect the traps at one- or two-day intervals during the whole season. Due to the requirements of other work which was carried on at the same time and insufficient assistance for a plan such as the above, the following scheme was adopted. Traps were placed in three series, those of each series at first centering about the Laboratory, Sales Yards and City Dump release points, the series being known respectively by these names. It was planned to place ten traps in each series and to collect them twice a week at alternating three- and four-day intervals. In the main this was followed, but variation from the schedule was sometimes necessary. Each series of traps was left at a given set of stations for only a few settings and then new stations were selected at constantly increasing distances. In this way it was possible to cover the whole city though some parts much more thoroughly than others. Stations of the Laboratory series were numbered from 1, those of the Sales Yards series from 101, those of the City Dump series from 201. Stores from which records were taken from sticky fly paper were assigned a station number corresponding to the locality.

With few exceptions the records are from Hodge traps placed out-of-doors. For the purposes of this work, which was to find in what localities the flies could be recaptured, the out-door results were all that were necessary and the use of traps instead of sticky fly paper permitted a larger number of flies to be captured. All in-door records are designated by reference to a foot-note. Beer and oatmeal were used as a bait for the traps.*

Method of Collecting Traps

When collecting traps the tops were removed and the hole for entrance plugged with cotton. The pans were rebaited and new tops put in place.

Method of Marking Flies

Stains Used.—Flies released from the several release points were stained as follows: Laboratory, acid fuchsin; Sales Yards, rosolic acid; City Dump, aqueous eosin; Washington School, trypanblau. Those released from the Sales Yards on August 5, 6 and 7, were stained with methylene green; this was done with the hope that by subsequent recaptures some idea could be obtained of the average life of the house-fly. The results were unsatisfactory, however.

Preparation of Stains.—Stains were prepared as follows: Acid fuchsin, 4 c.c., 10 per cent alcohol, 100 c.c.; rosolic acid, 4 c.c. dissolved

* In the work during 1914 it was found that beer and oatmeal were two to three times as efficient as beer alone and afforded a standard bait.

in 20 c.c. of 95 per cent alcohol and added to 180 c.c. of water; aqueous eosin, 4 c.c., water, 100 c.c.; trypanblau, 4 c.c., water, 100 c.c.; methylene green, 4 c.c., water, 100 c.c.

In preparing the rosolic acid solution it was found necessary to dissolve the crystals in 95 per cent alcohol and then add this solution to the water. The trypanblau used was old and but very slightly soluble in alcohol.

USE OF STAINS.—The stains were applied to the flies while in the traps by means of separate small glass atomizers, except that the Sales Yards flies captured in a larger trap were stained with spray from a large tin atomizer. The stain in all cases was applied at the point of release so that stained flies were never transported from one point to another.

METHODS OF KILLING AND DIFFERENTIATING FLIES

As soon as traps were brought into the laboratory each was placed in a five-pound lard pail and the flies killed by ether, which was found to be more satisfactory than chloroform.

For examination the flies were spread in a thin layer on a newspaper and were first sprayed with 50 per cent alcohol. Fuchsin, eosin and methylene green entered into solution and left a spot under each fly marked with these stains. The number of stained specimens was immediately recorded and the flies again sprayed with a weak alkaline solution (Na O H). Flies stained with rosolic acid became a bright scarlet and left a corresponding spot on the paper while trypanblau left a blue spot.

It sometimes happened that there was uncertainty regarding the color left on the paper, except, of course, when the mark was blue or green. The other stains were then differentiated by the following tests. The fly responsible for the spot in question was placed in a very small homeopathic vial and about ½ c.c. of 50 per cent alcohol added. If the stain was eosin the yellowish tint imparted to the solute was a distinct proof. Sometimes the amount of stain was so small that the tint was scarcely perceptible. In this case a small amount of the alkaline solution was added; if fuchsin was present the color disappeared, if eosin it remained constant, and if rosolic acid it became greatly intensified. If these tests were not decisive no record was kept. The process was repeated with the flies from each station.*

* At the end of the season a trap was examined which had been in place for a month at the Sales Yards. It was found that flies marked with rosolic acid yielded a yellowish brown color when sprayed with the alcohol solution. Possibly the acid underwent some chemical change during its long exposure to the air, but the scarlet color afterwards appeared when sprayed with the Na O H, but much fainter than normal. The records from this trap are not given.

In discussing previous experiments reference was made to a method utilized by the writer by which flies were allowed to mark themselves by feeding on colored sugar syrup. Such flies were afterwards identified by the colored contents of the alimentary tract which showed through the thin ventral membrane. When flies were sprayed at the Laboratory the stain was applied with the bait pan attached. The bait became highly colored with the fuchsin and flies fed on it both while it was in the pan and after it was dumped. During the summer it was noted that the majority of flies on the Laboratory windows showed that they had visited this colored bait. Such flies were also frequently recovered in traps. Several times the abdominal contents of flies from some of the traps placed in the Laboratory series were squeezed out and ten to twenty flies would be found which had apparently fed on the colored bait, though many times not enough had been eaten so that the color showed through. This color usually responded to the test for fuchsin given above. This was incidental to the actual experimental work and no records of such flies appear. Their number, however, always exceeded that of flies which had been stained externally. This method of marking flies has obvious disadvantages and was first used as a makeshift for lack of other means, but it does suggest a practical means of demonstrating the filth-to-food habit of flies. By placing colored bait at a privy or garbage accumulation any person can readily satisfy himself in this respect as the stained abdomens show up quite brilliantly when flies are seen on the windows.

The advisability of spraying stained flies with some solvent or intensifier of the stain used is a point worth emphasizing. At first flies were examined before spraying, but this was not only tedious, but a useless expenditure of time Stained specimens could only occasionally be detected whereas catches which yielded no results by this method were sometimes found to contain ten, twenty or even forty marked flies.

Summary of Data

Laboratory Series

First lot of flies released, July 12.
Last lot of flies released, August 11.
Number of lots released, 26.
Total number of flies released, 40,237.
Total *Musca domestica* released, 35,270.
Number of laboratory flies recaptured, 242.*
Number of stations at which recaptured, 45.

* *Musca domestica*, 234; *Phormia regina*, 2; *Muscina stabulans*, 6.

Longest distance at which recaptured within city limits, 1,966 yards.
Recaptured 700 yards beyond city limits on same side of city.

Sales Yards Series

First lot of flies released, July 20.
Last lot of flies released, August 16.
Number of lots released, 23.
Total number of flies released, 248,140.
Number of Sales Yards flies recaptured, 667.
Number of stations at which recaptured, 62.
Longest distance at which recaptured within city limits, 2,200 yards.
Longest distance at which recaptured, 3,070 yards (this was 700 yards beyond city limits on opposite side of city).

City Dump Series

First lot of flies released, July 21.
Last lot of flies released, August 12.
Number of lots released, 10.
Total number of flies released, 54,500.
Number of City Dump Flies recaptured, 69.
Number of stations at which recaptured, 20.
Longest distance at which recaptured within city limits, 2,333 yards.
Longest distance at which recaptured, 3,500 yards (nearly 2 miles). This was 700 yards beyond city limits on opposite side of city.

Washington School Series

First lot of flies released, July 23.
Last lot of flies released, August 12.
Number of lots released, 9.
Total number of flies released, 45,000.
Number of Washington School flies recaptured, 78.
Number of stations at which recaptured, 20.
Longest distance at which recaptured within city limits, 1,230 yards.
Longest distance at which recaptured, 2,000 yards (this was 700 yards beyond city limits).

This station was centrally located within the city, hence recaptures within city limits could not be at such great distances as from the other release points.

Combined Data for All Release Points

First flies released, July 12.
Last flies released, August 16.
Total duration of experiment, 39 days.
Total lots of flies released, 68.

Total number of flies released, 387,877.
Total number of flies recaptured, 1,056.
Total number of stations used, 91.
Total number of stations at which flies were recaptured, 78.
(Traps were not recovered from 8 stations, hence liberated flies were recaptured at 78 stations from a total of 83 from which flies were examined).
Combined total of days during which traps were placed, 680.
Longest distance at which flies were recaptured within city limits, 2,333 yards.
Longest distance at which flies were recaptured, 3,500 yards (nearly 2 miles).

Stations at which flies were recovered from 1 release point only: 2, 3, 4, 5, 7, 8, 9, 10 (these traps were moved before it was possible to make recaptures, except from Laboratory release point), 12, 17, 24, 25, 34, 35, 36, 37, 101, 103, 110, 111, 112, 113, 120, 122, 124, 128, 129, 212, 213, 223, 241, 242, total 32.

Stations at which flies were recovered from 2 release points: 104, 107, 115, 1, 15, 19, 20, 21, 26, 28, 29, 30, 32, 38, 59, 64, 204, 205, 209, 215, 217, 218, 219, 222, 239, 240, total 26.

Stations at which flies were recovered from 3 release points: 11, 18, 31, 33, 105, 109, 117, 118, 119, 121, 127, 165, 208, 211, 214, 220, total 16.

Stations at which flies were recovered from 4 release points: 62, 168, 216, 224, total 4.

Possibilities of Error

The methods used in counting and releasing show several possibilities of error. What would at first sight seem a most potent source was the fact that flies for release at the City Dump and Washington School were captured at the Sales Yards about a hundred yards from the Sales Yards release point and the possibility of capturing flies stained with rosolic acid and afterwards releasing them again at the two points mentioned is at once apparent. When the facts are considered, however, the danger of thus affecting the results becomes less obvious. Table II shows that out of 150,000 flies captured in a trap placed at the Sales Yards during two weeks (July 31 to August 13) only 197 Sales Yards flies were recaptured; that is, approximately one for every 750 released. The smaller Hodge traps were placed near this large one and it is fair to assume that they recaptured stained Sales Yards flies in the same ratio. Hence, since such flies were released at the City Dump and Washington School there would have been approximately 133 Sales Yards flies released at these two points.

TABLE II. LOCALITY OF RECAPTURE STATIONS; NUMBER OF MARKED FLIES RECAPTURED AT EACH STATION DURING EACH SETTING; NUMBER OF DAYS TRAPS WERE IN PLACE; DISTANCE IN YARDS FROM VARIOUS POINTS OF RELEASE

(L=Laboratory, S. Y.=Sales Yards, C. D.=City Dump, W. S.=Washington School)

Date	Location of Stations and Station Numbers	Number of Stained Flies Recaptured	Release Point	Number of Days	Distance of Dispersion in Yards
July 13	(1) 506 N. Lake[d]	1	L.	1	130
July 14	(2) 605 N. Lake	1	L.	2	100
	(10) 620 N. Lake	3	L.	2	100
July 15	(5) 710 N. Lake	1	L.	1	150
	(8) 610 N. Cottage Grove	1	L.	1	160
	(10) 620 N. Lake	1	L.	1	100
July 16	(2) 605 N. Lake	3	L.	1	100
	(3) 602 N. Lake	10[a]	L.	1	50
	(4) 707 N. Lake	2[b]	L.	1	160
	(10) 620 N. Lake	2[c]	L.	1	100
July 17	(1) 506 N. Lake[d]	1	L.	1	100
	(3) 602 N. Lake	7	L.	1	50
	(9) 714 N. Cottage Grove	1	L.	1	240
	(7) 1611 Phillips	1	L.	1	240
July 20	(8) 610 N. Cottage Grove	2	L.	3	160
	(9) 714 N. Cottage Grove	3	L.	3	240
	(10) 620 N. Lake	1	L.	3	100
July 23	(101) Alley, 6th to 7th	1	S.Y.	3	660
	(103) Alley, 5th to 6th	1	S.Y.	3	600
July 25	(84) 607 N. Custer (L.)[a]	1	C.D.		2,135
July 26	(12) 1605 Gordon	1	C.D.	4	1,966
	(18) 110 N. Center	1	L.	5	500
	(19) 200 N. Jordan	19[e]	L.	5	500
July 27	(101) Alley, 6th to 7th	6	S.Y.	4	660
	(109) House near Sales Yards	2	S.Y.	4	200
		1	C.D.	4	800
July 28	(208) 115 N. 5th	3	S.Y.	4	660
	(209) 119 N. 5th	1	S.Y.	4	660
	(211) 123 N. 5th	1	S.Y.	4	700
	(214) 511 Palmer	4	S.Y.	4	800
		1	C.D.	4	760
		1	L.	4	1,400
July 29	(11) 613 N. Center	2	L.	3	330
		1	C.D.	3	500
	(15) 204 N. Lake	1	L.	3	500
July 30	(107) Hotel, 6th	1	S.Y.	3	500
	(109) House near Sales Yards	3	S.Y.	3	200
	(110) Cafe, 18 S. 6th	5	S.Y.	3	600
	(111) Hotel, 22 S. 6th	11	S.Y.	3	600
July 31	(204) Alley, 5th to 6th	4	S.Y.	3	600
	(205) Alley, 5th to 6th	1	S.Y.	3	630
	(214) 511 Palmer	3	S.Y.	3	800
	(216) 117 N. 7th	1	S.Y.	3	830
Aug. 1	(168) Sales Yards	1[o]	W.S.		1,130
Aug. 2	(1) 506 N. Lake[d]	12	L.	4	130
	(11) 613 N. Center	1	L.	4	330
	(20) 715 N. Jordan	5	L.	4	200
Aug. 3	(103) Alley, 5th to 6th	6	S.Y.	4	600
	(104) Alley, 5th to 6th	8	S.Y.	4	533
		3	W.S.	4	600
	(105) Cafe, 6th	6	S.Y.	4	530
	(107) Hotel, 6th	42	S.Y.	4	500
		6	W.S.	4	630
	(109) House near Sales Yards	42	S.Y.	4	200
		6	W.S.	4	960

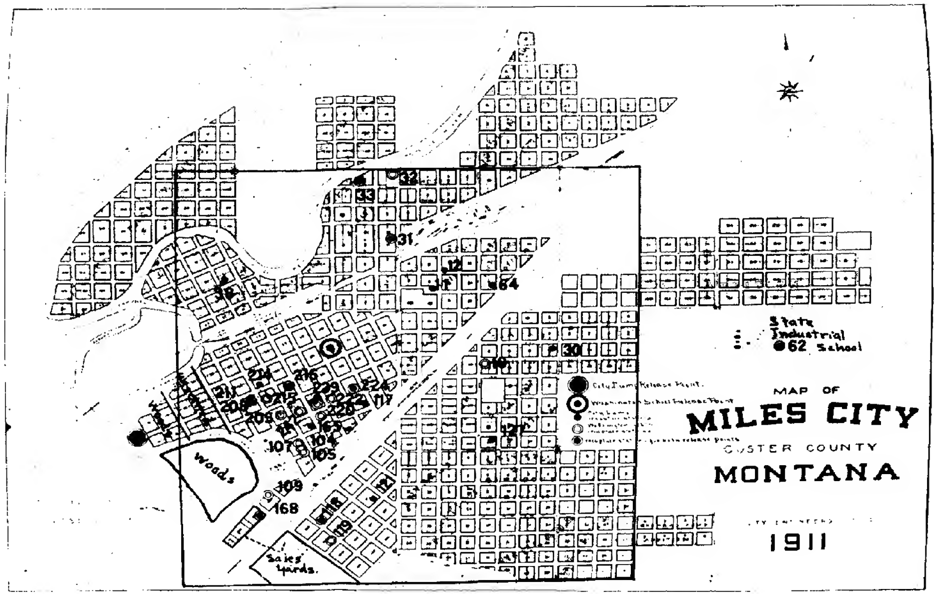
Date	Location of Stations and Station Numbers	Number of Stained Flies Recaptured.	Release Point	Number of Days	Distance of Dispersion in Yards
	(111) Hotel, 22 S. 6th	9	S.Y.	4	600
Aug. 4	(204) Alley, 5th to 6th	14	S.Y.	4	600
		2	L.	4	600
	(205) Alley, 5th to 6th	2	S.Y.	4	630
	(208) 115 N. 5th	6	S.Y.	4	660
		1	L.	4	1,500
		2	C.D.	4	660
	(209) 119 N. 5th	1	S.Y.	4	660
	(211) 123 N. 5th	3	S.Y.	4	700
		3	L.	4	1,500
		1	C.D.	4	660
	(213) 508 Palmer	3	S.Y.	4	730
	(214) 511 Palmer	1	S.Y.	4	800
		1	L.	4	1,400
	(212) 122 N. 5th	3	S.Y.	4	730
	(216) 117 N. 7th	14	S.Y.	4	830
		1	L.	4	1,260
Aug. 5	(1) 506 N. Lake	4	S.Y.	3	1,830
		9	L.	3	130
	(11) 613 N. Center	1	S.Y.	3	1,730
		2	L.	3	330
	(15) 204 N. Lake	3	S.Y.	3	1,700
		2[f]	L.	3	500
	(17) 20 N. Lake	3	S.Y.	3	1,600
	(18) 110 N. Custer	2	S.Y.	3	1,730
		1	L.	3	500
		6	W.S.	3	930
	(19) 200 N. Jordan	3	S.Y.	3	1,860
		8	L.	3	500
	(21) 805 N. Jordan	2	S.Y.	3	2,200
		5	L.	3	266
		9	S.Y.	3	530
Aug. 6	(105) Cafe, 6th	1	L.	3	1,430
		3	W.S.	3	630
	(112) Alley, 7th to 8th	3	S.Y.	3	730
	(113) Alley, 7th to 8th	2	S.Y.	3	760
	(115) Alley, 8th to 9th	3	S.Y.	3	1,130
		1	L.	3	1,130
	(117) Market, Main St.	2	S.Y.	3	930
		1	L.	3	1,000
		1	C.D.	3	1,280
	(59) Grocery, 8th	3	S.Y.	1	1,100
		4	L.	1	1,100
Aug. 7	(205) Alley, 5th to 6th	2	S.Y.	3	630
		2	W.S.	3	460
	(209) 119 N. 5th	4	S.Y.	3	660
		3	L.	3	1,500
	(211) 123 N. 5th	3	L.	3	1,500
	(213) 508 Palmer	2	S.Y.	3	730
		1[m]	S.Y.	3	730
	(214) 511 Palmer	3	S.Y.	3	800
		7	L.	3	1,400
	(215) 112 N. 5th	1	L.	3	1,430
		1	W.S.	3	560
		14	S.Y.	3	830
	(216) 117 N. 7th	12[m]	S.Y.	3	830
		12	L.	3	1,260
		16	W.S.	3	300
Aug. 9	(24) 717 Prairie	1	S.Y.	3	1,800
	(25) 718 Prairie	1	S.Y.	3	1,830
	(26) County Hospital	1	S.Y.	3	2,000
		1[m]	S.Y.	3	2,000
		4	L.	3	266

TABLE II—*Concluded*

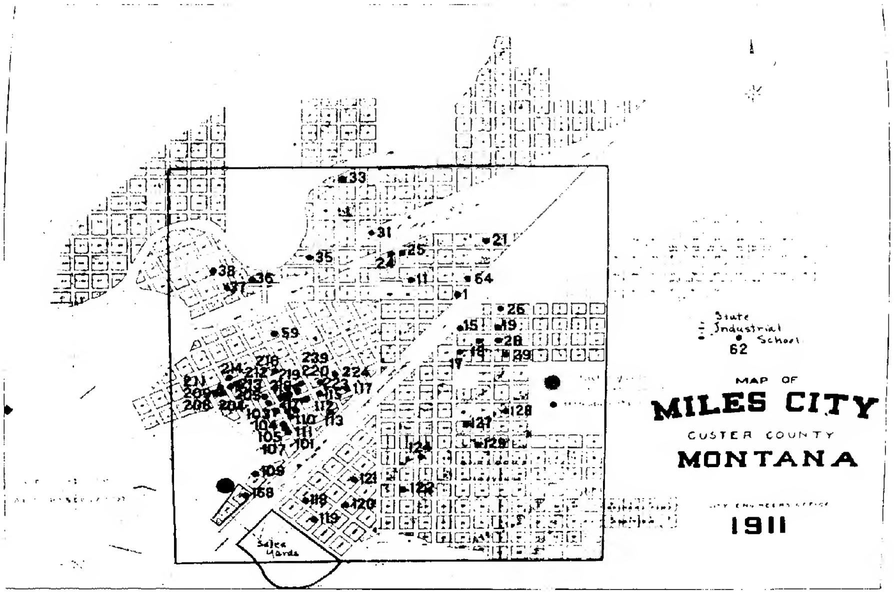
Date	Location of Stations and Station Numbers	Number of Stained Flies Recaptured	Release Point	Number of Days	Distance of Dispersion in Yards
	(28) 106 N. Jordan	1[m]	S.Y.	3	1,830
		2[h]	L.	3	433
	(29) 19 N. Merriam	5	S.Y.	3	1,830
		3[m]	S.Y.	3	1,830
		1	L.	3	533
	(30) 119 N. Strevell	1	C.D.	3	2,333
		2	L.	3	500
Aug. 10	(105) Cafe, 6th	7	S.Y.	4	530
	(118) 501 Yellowstone	1	S.Y.	4	460
		1[m]	S.Y.	4	460
		3	C.D.	4	1,130
		1	W.S.	4	1,100
		5	S.Y.	4	560
	(119) 415 Missouri	1[m]	S.Y.	4	560
		2	L.	4	1,830
		2	W.S.	4	1,230
	(120) 604 Missouri	1	S.Y.	4	700
		2[m]	S.Y.	4	700
	(121) 717 Missouri	3	S.Y.	4	730
		3	L.	4	1,500
	(124) 510 S. Center	2	S.Y.	4	1,130
		1[m]	S.Y.	4	1,130
Aug. 11	(217) Alley, 6th to 7th	1	S.Y.	4	660
		1	L.	4	1,330
	(218) Alley, 6th to 7th	1	S.Y.	4	700
		1	L.	4	1,300
	(219) Alley, 6th to 7th	2	S.Y.	4	700
		4	L.	4	1,300
	(220) Alley, 7th to 8th	4	S.Y.	4	760
		1	L.	4	1,230
		2	W.S.	4	400
	(222) Alley, 8th to 9th	1	L.	4	1,130
		1	W.S.	4	300
	(223) Alley, 8th to 9th	3	S.Y.	4	900
	(224) Alley, 9th to 10th	2	S.Y.	4	960
		4[m]	S.Y.	4	960
		6	L.	4	1,000
		1	C.D.	4	1,200
		1	W.S.	4	260
Aug. 12	(118) 501 Yellowstone	1	S.Y.	2	460
	(119) 415 Missouri	1	L.	2	1,830
	(120) 604 Missouri	1	S.Y.	2	700
	(121) 717 Missouri	1	S.Y.	2	730
		1	C.D.	2	1,360
	(122) 710 S. Prairie	1	S.Y.	2	1,030
	(124) 510 S. Center	3	S.Y.	2	1,130
	(216) 117 N. 7th	7	S.Y.	2	830
		6	L.	2	1,260
		2	C.D.	2	900
		1[m]	S.Y.	2	830
	(31) 811 N. Montana	8	S.Y.	2	1,830
	(32) 1101 N. Montana	1	W.S.	2	1,100
	(33) 1116 N. Garland	2	S.Y.	2	2,100
	(36) 725 Phillips	1	S.Y.	2	1,360

Date	Location of Stations and Station Numbers	Number of Stained Flies Recaptured	Release Point	Number of Days	Distance of Dispersion in Yards
	(37) 707 N. 7th	4	S.Y.	2	1,330
	(38) 600 Hubble	5	S.Y.	2	1,400
		1	CD	2	1,100
Aug. 13	(240) 801 Main St.[g]	2	S.Y.	?	1,130
		2	L.	?	1,130
	(241) 823 Main St.[g]	1	S.Y.	?	900
		1[m]	S.Y.	?	900
	(165) 720 Main St.[g]	4	S.Y.	?	1,200
		1	W.S.	?	370
	(31) 811 Montana	3	L	?	1,500
		4	S.Y.	2	1,830
		2	C.D.	2	1,830
		1	W.S.	2	700
	(32) 1101 Montana	1	L.	2	1,100
	(33) 1116 Garland	4	S.Y.	2	2,300
		10	C.D.	2	1,966
		8	W.S.	2	1,000
	(34) 1001 Woodberry	1	L.	2	1,033
	(35) 707 Woodberry	1	S.Y.	2	1,560
	(38) 600 Hubble	3	S.Y.	2	1,406
		1	C.D.	2	1,100
	(127) 301 S. Custer	4	S.Y.	2	1,430
		1[m]	S.Y.	2	1,430
		3	C.D.	2	1,930
	(128) 215 S. Merriam	1	S.Y.	2	1,760
	(216) 117 N. 7th	23	S.Y.	2	830
		2[m]	S.Y.	2	830
		6	L.	2	1,260
		12	C.D.	2	900
		2	W.S.	2	300
	(168) Sales Yards	28	L.	14	1,966
		16	C.D.	14	800
		5	W.S.	14	1,130
		197	S.Y.	14	100
Aug. 15	(64) 607 N. Custer	2	S.Y.	1	1,966
Aug. 17	(127) 301 S. Custer	1	S.Y.	2	1,430
		1	L.	2	930
Aug. 18	(64) 607 N. Custer	4	S.Y.	1	1,966
Aug. 19	(242) Main St.[g]	1	W.S.	?	460
	(239) Main St.[g]	1	S.Y.	?	765
		1	C.D.	?	840
	(224) Main St.[g]	1	L.	?	1,000
	(129) 412 S. Custer	1	S.Y.	5	1,460
	(216) 117 N. 7th	1	L.	5	1,260
	(168) Sales Yards	6	S.Y.	3	100
		9	L.	3	1,966
		1	C.D.	3	600
Aug. 20	(62) State Industrial School	29	S.Y.	11	3,070
		2	L.	11	1,430
		5	C.D.	11	3,500
		4	W.S.	11	2,000
Aug. 21	(168) Sales Yards	1	L.	5	1,966
		4	W.S.	5	1,130
	Totals	1,056			

[a] *Musca domestica*, 8; *Muscina stabulans*, 2.
[b] *Musca domestica*, 1; *Phormia regina*, 1.
[c] *Musca domestica*, 1; *Phormia regina*, 1.
[d] Trap set inside.
[e] *Musca domestica*, 17; *Muscina stabulans*, 2.
[f] *Musca domestica*, 1; *Muscina stabulans*, 1.
[g] Record from sticky fly paper exposed inside.
[h] *Musca domestica*, 1; *Muscina stabulans*, 1.
[m] Methylene green.
[n] This fly was captured on a laboratory window and the chance that it may have been brought back on the clothes of the person releasing the flies is not improbable.
[o] Observed.



Stations at which Laboratory Flies were Recaptured
(Heavy lines enclose all built-up sections of city)



Stations at which Sales Yards Flies were Recaptured
(Heavy lines enclose all built-up sections of city)

But since the season totals show that only one of every 366.5 flies stained was recovered the possibility of error becomes insignificant. Furthermore, such flies would have been stained twice and if captured their color reactions would probably not have been normal and such records would have been disregarded.

Another source of error was the fact that the number of flies released was estimated in all cases. At the Laboratory the number of each species was estimated and these figures are perhaps the nearest correct. The Sales Yards figures are small, rather than large, but the numbers in the City Dump and Washington School series are likely to have been overestimated. The flies from these traps were released at successive intervals of two, two and three days. They were usually well filled and many flies must have died because of their long captivity in such close quarters. This fact was considered when estimates were made, but the writer feels that the latter, nevertheless, were too high.*

The possibility of carrying stained flies on clothing was guarded against by careful examination before leaving the various release points.

Concerning Factors of Dispersion

The following factors have been suggested by previous writers as concerned in fly dispersion: wind, temperature, state of weather, nature of locality, height at which flies are liberated and the time of day at which liberated. When we consider that dispersion concerns the sum total of flies migrating from a breeding ground during the breeding season, these terms seem to have less significance than may be the case when dealing with short periods of time. The writer prefers to consider seasonal dispersion as the combined result of tropisms, or responses to stimuli, which are active during the whole season, but vary in intensity and duration. Observations of short duration may be of value to demonstrate the dominance of some one stimulus for a short time, but from the standpoint of seasonal results this stimulus may be reduced to a point of insignificance. For instance, a certain stimulus (wind, for example) may cause flies to migrate in one direction on one day, in another the next and so on, but when the results are examined in toto for the experiment in its whole duration it is found that flies are more or less equally distributed in all directions which would presumably have been the case if this stimulus had never existed. This factor or stimulus, then, can be eliminated as having any more than an incidental effect on the ultimate distribution.

* During the season of 1914 the writer and his assistant counted large numbers of flies in Hodge traps and became accustomed to estimating the numbers of flies contained.

That is, on the basis of averages, the counterbalancing effects of certain stimuli will incidentally balance each other if long enough periods are considered.

For the purposes of discussion those so-called factors of dispersion which are themselves stimuli or the sources of stimuli may be separated into three divisions—physical, physiographical and physiological.*

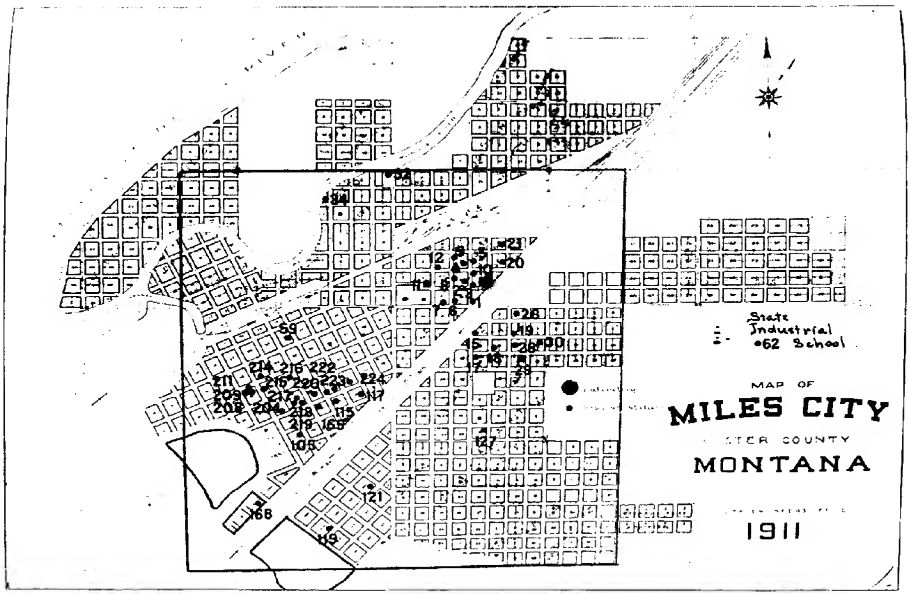
Physical

Wind.—As previously noted, Hewitt has suggested that flies will travel with the wind (negative anemotropism), while Hindle claims that they fly against or across the wind (positive anemotropism). From an unbiased standpoint both statements seem reasonable, given the proper conditions. Hewitt's observations would indicate that, under certain conditions, flies are stimulated to fly with the wind, but was not this stimulus dominant because others were comparatively less intense? In the case of Hindle's observations, the reaction of the flies was positively anemotropic in result, but the stimulus may have been due to odors borne by the wind so that the actual reaction was really chemotropic, the wind acting as an agent to convey the stimulus.

In conducting the summer's work an attempt was made to determine to just what extent, under city conditions, wind served as a stimulus to migratory movement. Careful examination of data has failed to give proof of a positive character. For illustration let us examine the data of Tables III and IV. The former is a record of stained flies recovered at Station 216 during a period of twenty days from July 30 to August 19. A total of 132 such flies were captured, seventy-four from the Sales Yards, twenty-six from the Laboratory, eighteen from the Washington School and fourteen from the City Dump. During the same period Table IV shows that the wind varied from north to south through east, the majority of the records reading north, northeast or east.

Station 216 is about centrally located with the Laboratory and Washington School release points to the east and the City Dump and Sales Yards release points to the west (See Plate 23). The wind, then, as far as records show, blew from the direction of the Laboratory and Washington School toward this station and the other release points beyond for a considerable part of the period in question, but never from the opposite direction. Considering Sales Yards versus Laboratory flies, we find that 248,140 flies were released from the Sales Yards

* This division is not exact. It might be better if vital were substituted for physiological, as the stimuli herein referred to as physiological arise from sources vital to fly life, that is, from feeding areas and breeding areas.



Stations at which City Dump and Washington School Flies were Recaptured
(Heavy lines enclose all built-up sections of city)

Showing Recapture Station 216 and the Release Points

Table III. Record of Recapture Station 216

Dates	Total stained flies Recovered	Number of flies from Laboratory, 1,260 yards	Number of flies from Sales Yards, 830 yards	Number of flies from City Dump, 900 yards	Number of flies from Washington School, 300 yards
July 30–July 31	1		1		
July 31–Aug. 4	15	1	14		
Aug. 4–Aug. 7	54	12	26		16
Aug. 7–Aug. 12	16	6	8	2	
Aug. 12–Aug. 14	45	6	25	12	2
Aug. 14–Aug. 19	1	1			
Totals	132	26	74	14	18

Table IV. Miles City Meteorological Data: Direction and Velocity of Wind; Precipitation; Temperature (July 12 to August 20)*†‡

Date	Wind direction		Wind velocity	Precipitation	Temperature	Date	Wind direction		Wind velocity	Precipitation	Temperature
	6 A. M.	6 P. M.	Miles per hour (av'rage)	Inches T= trace	Maximum and minimum		6 A. M.	6 P. M.	Miles per hour (av'rage)	Inches T= trace	Maximum and minimum
July 12	W.	N.	4	0	84 60	Aug. 1	N.	N.	6	0	68 58
13	W.	N.	7	0	82 60	2	N.	S.E.	4	0	75 55
14	N.E.	N.	5	0	80 60	3	E.	E.	8	0	82 56
15	W.	M.	6	.14	73 59	4	E.	E.	4	0	92 63
16	S.	E.	3	1.02	82 54	5	E.	E.	4	0	92 65
17	E.	N.	6	.12	72 56	6	N.	E.	4	0	88 62
18	W.	N.	6	0	64 54	7	S.E.	N.E.	4	0	90 62
19	S.E.	N.E.	3	T	72 45	8	S.E.	S.E.	5	0	90 62
20	N.	N.	3	0	79 50	9	S.E.	N.E.	3	0	91 66
21	S.	S.E.	3	.75	84 54	10	S.	E.	2	0	92 62
22	S.	N.E.	3	.17	92 60	11	N.E.	E.	6	.04	92 60
23	S.W.	N.	5	0	93 62	12	N.	N.E.	3	0	90 60
24	W.	N.	6	0	78 58	13	S.	N.E.	3	0	86 61
25	N.E.	E.	6	.50	80 58	14	N.E.	N.E.	4	0	90 60
26	N.	N.	5	0	77 58	15	N.E.	N.E.	4	.14	90 66
27	N.E.	E.	4	0	78 56	16	S.E.	E.	6	1.02	90 62
28	E.	S.W.	4	0	84 61	17	S.E.	N.E.	6	12	91 60
29	S.W.	S.E.	3	0	85 58	18	S.E.	N.E.	3	0	88 64
30	N.	E.	3	0	81 57	19	N.E.	N.E.	4	T	88 63
31	N.E.	N.E.	3	0	83 58	20	W.	N.E.	4	0	82 62

* The writer is indebted to the United States Weather Bureau for the data in this table. It is not the data which would be the most significant in all cases but the best available.

† The writer is also indebted to the Weather Bureau for the following data which show the average hourly wind velocity (miles per hour) at Miles City and at several of the large cities in the east during the months of June, July and August respectively: Miles City, Mont., 6, 5, 4; Boston, Mass., 9, 8, 9; New York, N. Y., 13, 12, 14; Philadelphia, Pa., 10, 8, 8; Atlantic City, N. J., 9, 7, 8; Washington, D. C., 6, 5, 5.

‡ These records were taken at 6.00 a. m. and 6.00 p. m. hence, there is a possibility that midday records might be different.

(1,260 yards from the station) and 40,237 from the Laboratory (830 yards from the station). Do not the respective totals of seventy-four and twenty-six flies recovered from these release points bear a more direct relation to the comparative distances and numbers released than to any consideration of wind direction or wind velocity that can be deduced? A similar review of the data concerning the other two release points gives no essentially different results. This seems to indicate, then, that as a stimulus having any effect on ultimate dispersion in a given direction from a breeding area when a long period of time is concerned, wind may be a negative factor, and in this particular citation there is no evidence to demonstrate any influence of wind as a stimulus when the shorter periods of time concerned are considered.

If Hindle's idea of dispersion against and across the wind has a true significance in the economy of fly dispersion, it would seem capable of interpretation in the following way. Without the assistance of air currents, odors originating at any given point have the ability to diffuse through the atmosphere and within a certain radius would logically be sufficiently concentrated to serve as a positive chemotropic stimulus. A point must eventually be reached, however, at which the diffusion is so great that all power of stimulation is lost.

It may well be that a light breeze will serve to so strengthen the odor beyond this point so that the power of stimulation will extend beyond its normal radius. In the opposite direction the distance of possible stimulation would be decreased or reduced to nothing. Yet, in this case the wind serves rather to increase the distance to which an already active factor is at work in a certain direction than to act as a factor itself, unless it be that it exerts a stereotropic influence.

Another point still further complicates the discussion. Flies have been repeatedly referred to in literature as seeking "shelter." Certain it is that when meteorological conditions are unfavorable they are little in evidence. This suggests that if the wind be too strong flies may seek protection.

Although the data of the present investigations indicate that wind, as a seasonal factor, may have had little significance, it is by no means proved that this would be so under all conditions. Munson (1901),[9] concerning the typhoid epidemics of 1898, says that "when a strong wind constantly blows from the same direction, a fly-borne infection will extend down the wind."

Rain.—Flies are not active during inclement weather, hence dispersion is temporarily affected because of lessened activity.

Temperature.—The same consideration applies to low temperatures. Optimum temperatures, on the other hand, increase activity.

favoring both more rapid breeding and greater distribution. It may justly be considered a seasonal factor, its influence being present at all times, either in a positive or a negative manner

Physiographical

Elevations and Depressions.—Zetek, in discussing his experiments at Ancon, Panama, expressed his belief that flies follow depressions, rather than to cross elevations. How much importance is to be attached to this point when considering dispersion under city conditions is not entirely apparent. It may have some significance when considering congested areas and high buildings which offer parallel conditions on a small scale. Whatever stimulus might prompt flies to follow a depression in natural topography, other additional stimuli would be active in a city (presence of food, etc.).

Bodies of Water.—Hewitt's experiment at Ottawa demonstrated that streams passing through a city are not a barrier to fly dispersion and Hodge's observations at Lake Eric indicate that considerable bodies of water may be crossed.

Wooded Areas.—The summer's results indicate that wooded areas of small extent and of an open character are not an obstacle to the spread of flies. In order to reach the city from the City Dump release point it was necessary to traverse a wooded area 200 yards in width or to take a roundabout course up the old channel of the Tongue river, shown on the map. In the latter case it was necessary to pass through woodland, but of less extent. City Dump flies captured at the Sales Yards, 800 yards distant, may have followed up the Tongue river, have passed through or over almost continuous woods in the most direct line or have taken a more devious course by way of the city itself.

Physiological

To live and reproduce are functions of all animal life, both essential to the perpetuation of the species, but the second highly dependent on the first. As entomologists we are acquainted with many obvious instances where adult life is entirely devoted to feeding and reproduction, and if there are any two facts that are always in evidence concerning the house-fly they are its presence at feeding and breeding grounds. These facts, then, indicate the two factors of prime importance which, given normal conditions, seem to be largely responsible for the migratory movements of the house-fly under city conditions--namely the stimuli from feeding areas and the stimuli from breeding areas. These apparently are chemotropic and to them the fly seems to react positively to a far greater extent than to any other stimuli which cause movement, though it is obvious that various

physical stimuli may acquire incidental or temporary dominance, but would have little effect on seasonal distribution. Isolated cities or localities, however, are of undoubted occurrence, where some one physical factor might exert its stimulus continuously for a long period or even a whole season and hence become one of major importance (Munson, l. c.).

In poorly kept cities flies are quite generally distributed, but there are usually areas of unusual abundance due to their advantages as good feeding and breeding grounds. Such areas may be large as a poorly cared for market district or a breeding ground of many acres such as the Miles City Sales Yards, and they may be small as in the vicinity of poorly kept residences or stables. To show how such areas exert a stimulus influencing migration, let us consider Station 216 again. The house, a boarding place, was very clean, but a manure pile, privy with open door and uncovered seats, several accumulations of garbage and a privy with an open vault in the next yard (Pl. 26, figs. 8 and 9) were efficient attractions and because of these, flies were abundant in the vicinity of the house. At this station (at the backdoor of the house) 132 stained flies were recovered in twenty days. The total number of days represented in the whole experiment was 680, yet in twenty (one-thirty-fourth of whole time) this station attracted one-eighth the total catch.

The State Industrial School, which is 700 yards east of the outside limits of Miles City, is another example. Flies were very abundant, especially at the pig house 150 yards to the east and at a shack for mixing garbage for the pigs nearer the main buildings. The pig house was 3,500 yards from the City Dump, 3,070 from the Sales Yards, 2,000 from the Washington School and 1,430 from the Labotory. On August 9, nine traps were placed, two inside the pig house, one at the garbage shack and the others at the barns, poultry houses, etc. The traps were collected on the 20th of August and twenty-nine Sales Yard, four Washington School, five City Dump and two Laboratory flies recaptured. Except for a few in the trap at the garbage shack, all were recaptured at the pig house about which flies were breeding in stupendous numbers. These flies had not only crossed Miles City, but the 700 yards of open country intervening and for the most part had selected the pig house as their goal. The isolated location of the school doubtless rendered the apparent attracting stimulus from the pig house doubly effective, while the flies about the main buildings were perhaps migrants from this breeding ground.

In presenting these illustrations the object is to show that the fly is essentially a migratory insect, the migration, in the main, seeming to depend upon the two stimuli under discussion, and also that it is

a false idea to assume that when flies breed out near "food and shelter" they necessarily do not migrate far. Let us further illustrate. It is known that the house-fly deposits several batches of eggs at several intervals. Yet, in general, feeding areas are not breeding areas; large districts suitable for feeding may lack breeding facilities. Hence, must not the fly continually migrate from one to the other? That it does so is evidenced by the fact that 85 to 95 per cent are conceded to breed out in horse manure, yet we do not find that percentage of the adults normally in its vicinity. This indicates that the stimulus from breeding areas may at times transcend that from feeding areas and vice versa impelling consequent migrations. Hutchinson (1915)[11] presents evidence along this line. Recently emerged flies were marked and liberated at a dairy barn about 700 yards distant from a stable and a kitchen. Of two of the lots liberated flies were recovered at the kitchen, but none at the stable.

Another observation from the summer's work may well be noted. The Miles City Sales Yards afforded extensive breeding facilities. As long as certain physical factors permitted breeding, flies were always present in enormous numbers, but during several periods factors which will be dealt with in another paper practically eliminated breeding, though manure was as abundant as ever. Immediately the number of flies began to decrease, simply due to migration without any compensating emergence of adults.

The House-Fly Essentially a Migrating Insect

After due consideration of these results and those of others it is impossible to escape the conviction that the house-fly under Montana conditions is essentially a migratory insect and not necessarily within localized areas. It is constantly moving from the field of one stimulus causing tropic reactions (that is, movements to or from) to that of another. Looking at Plate 21, which shows the dispersion of flies from the Sales Yards, does not the fact that flies were recaptured at this, that or the other place have an added significance beyond mere locality and distance. It means that each locality capable of attracting these flies became a subsidiary center for further distribution. The Sales Yards were an immense breeding ground. An extremely small proportion of their product was stained and recovered as shown, and that seventy-six of the released flies were captured at Station 216 means that this was only a small portion of the Sales Yards flies that actually reached this point. From it they spread to other localities and the station thus became a center of distribution subsidiary to that of the Sales Yards. This means that breeding and feeding areas are not necessarily areas which attract flies and retain them, but that

they may be considered as substations, so to speak, which aid and abet distribution and further increase the final radius of dispersion. Several reasons that may influence flies to leave such localities to which they have been attracted may be suggested. It is known that flies seek "shelter" at night. Where abundant the writer has seen them collect in the late afternoon by the thousands under the eaves and on the walls, especially on the south and west sides, of houses and buildings. It is apparent, then, that to reach such places a fly must leave the immediate vicinity of any feeding ground or breeding ground at which it was busy and there is no particular reason apparent why a fly should return to the same place when it resumes its activity in the morning. Indeed, whatever stimulus a feeding or breeding place may exert at midday under a strong sun would seem likely to be less intense in the cool of the morning. Similarly after a rain, stimuli may be less intense. Showers and changes of temperature may also cause flies to seek "shelter" and again it is a reasonable question to ask if there is any stronger reason why a fly should return to the place of its activities just before such an interruption than that it should go in some other direction? The direction of wind may have changed, and if stimuli may be wind-borne, which there is no good reason to doubt, may not the fly receive a stimulus from an entirely different direction? Other possible reasons for migration may be disturbance (flies in a business portion of a city are constantly being disturbed) and the removal of garbage, refuse, manure, etc., which serve as an attraction. Whether or not the fly can be said in general to leave a feeding or breeding place in response to other stimuli from similar places may be questioned. Indeed, an innate wandering instinct may sometimes be the cause but even then may not the direction of flight be controlled by external stimuli and since it is at feeding and breeding areas that flies are commonly found in abundance, is it not unreasonable to suppose that flies are sooner or later attracted by stimuli emanating from them, though such stimuli may perhaps not be correlated with the reason which initiated the movement? There is no apparent reason to assume that flies will necessarily stop at feeding or breeding areas nearest at hand.

Hindle has suggested the height of the point of liberation and the time of day are factors influencing the distance of dispersion. Bearing in mind that dispersion is primarily a problem of spread *from breeding areas* and that the life of a fly is a matter of several weeks, it is hard to assign a true significance to these points. Certainly it seems as if it would make very little difference in the ultimate distance a fly will have traveled whether it emerged from its puparium in the morning

or evening. The height of the point of liberation may well affect the initial flight, but scarcely more.

This discussion concerning the factors of dispersion has necessarily been brief in order that it might not be unduly complicated. Other stimuli, such as phototropism and heliotropism might have been considered; undoubtedly they play their part in a minor way. Nor have all the ideas suggested by dealing with dispersion as a result of external stimuli been discussed in detail. Three further points should be mentioned. First, that stimuli acting at any given time may be considered as active or passive according as they do or do not cause a reaction on the part of the fly. Passive stimuli might well be termed latent. A stimulus active at one time may be passive at another and of several existing at the same time one may be active, the others passive. And again, active stimuli may be divided on the basis of their effect on movement or dispersion,—that is, some stimuli cause *movements* or *tropic responses* (stimuli from feeding and breeding areas, etc.), which result in dispersion, while others may cause inactivity (low temperatures, rain, etc.) which delays dispersion. The former are termed *inciting*, the latter *inhibiting*. When active some stimuli may be always inciting, while others may be always inhibiting, or the same stimulus may sometimes be inciting, sometimes inhibiting, depending on its quality and intensity as compared with other stimuli.

The second point concerns the standpoint from which the question of stimuli is viewed. The writer has considered them to be external and resultant movements as not in any way instinctive. Others, however, might choose to say that the stimuli which govern a fly's movements are of internal origin. As far as can be foreseen any arguments in support of this opinion can be equally well explained on the basis of external stimuli. For example, one might say that when the ova become mature the fly instinctively seeks a suitable breeding ground; but, on the other hand, it may well be suggested that the maturing ova cause some physiological change which makes the fly more receptive to the stimuli "thrown out" from such areas. Indeed, physiological changes must constantly be taking place and probably often determine the manner in which a fly reacts to the complex of stimuli which are constantly at work.

The third point concerns the fact that the results of this investigation have indicated that the distance to which flies may spread from any given breeding area under city conditions in Montana is considerably greater than that found in previous experiments in other localities. Considering that dispersion has to do with the spread of flies from a breeding ground, it at once becomes apparent that no

limit can safely be placed unless the time concerned is at least as long as average fly life and the number of flies in some measure approaches that number which we would expect to find emerging from a medium sized breeding area during the period of time concerned. In fact, to obtain the results desired, the number of flies used would have to be greatly in excess of this. But when we consider that in all previous experiments probably less than 50,000 flies were used and that the largest number used in any one experiment was 25,000, it is at once suggested that the difference in the númbers of flies used explains the difference in results (nearly 390,000 in this work). The explanation is as follows. It is a fair assumption that under normal conditions flies from any breeding area will spread in all directions, but will be most abundant at nearby feeding areas. From this "zone" of greatest abundance the ultimate resúlt of fly migration will be outward though the number in the "zone" itself would be kept reasonably constant by continual additions from the breeding ground. It is apparent that, in a dispersion experiment using small numbers of flies, as they spread outward they become constantly fewer and fewer for any given unit of territory and consequently more and more scattered until a point is finally reached where the chances of recapture become reduced to infinity even though flies be actually present. But if the number of flies released is indefinitely increased, the possible number of flies per unit of territory at long distances is increased and consequently the possible limit of capture becomes constantly more and more distant until finally a "true" limit is reached, the actual location of which is dependent on the length of life of the average fly, while its actual determination must be based on experiment continued for this length of time and the use of a sufficiently large number of flies to permit their recapture at the dispersion limit. While this idea is merely offered as a possible explanation of why the results secured at Miles City differ so materially from earlier observations, it suggests as well that, by using a sufficiently large number of flies for a sufficiently long time and by making observation over a sufficiently large area, results could perhaps be obtained that would have more or less general application under balanced conditions.

Concerning Dispersion Over Open Country

No evidence of particular value was collected concerning dispersion across open country. On the 14th of August, 5,000 flies marked with gentian violet were liberated at a point midway between Fort Keogh and Miles City (Pl. 24, fig. 3). The prairie was barren for the intervening mile in each direction. A trap from the Sales Yards examined on August 21 contained thirteen of these flies and one from Keogh

examined on August 26 contained one. In order to reach the Sales Yards the flies had to cross a river several hundred feet wide. Fort Keogh was very clean and sanitary.

Evidence previously submitted showed that flies from breeding grounds within the city which was liberally spotted with attractive feeding and breeding areas, not only crossed it but 700 yards of open country beyond. This indicates that not only are breeding grounds outside a city of concern to its inhabitants, but that insanitary conditions within a city may also concern outside residents.

In respect to factors influencing dispersion across open country, the writer is again of the opinion that the two big factors are the stimuli from feeding and breeding areas, but with these differences: first, that such areas are relatively of small size; second that they are much farther apart; third, that the stimuli "thrown out" are weaker, and fourth, that other active stimuli may exert a relatively greater influence and act for relatively longer periods of time. Thus, in its existence in nature as undisturbed by man's occupation, we are justified in considering the house-fly as primarily a migratory insect.

Concerning General Distribution, Time of Distribution and Numbers of Flies

General Distribution.—From the data given on the maps it can be seen that flies from the several release points become quite generally distributed over the entire city and spread even beyond its limits. An examination of the data in Table II gives ample evidence on this point. A trap placed at Station 214 for four days (July 24 to 28) captured flies from the Sales Yards, City Dump and Laboratory; one placed at Station 208 for four days (July 31 to August 4) captured flies from the same three release points; one placed at Station 105 for three days (August 3 to 6) captured flies from the Sales Yards, Laboratory and Washington School; one placed at Station 119 for four days (August 6 to 10) also captured flies from these three release points; one placed at Station 224 for four days (August 7 to 11) captured flies from all four release points; one placed at Station 33 for two days (August 12 to 14) captured flies from the Sales Yards, City Dump and Washington School; one placed at Station 127 for three days (August 14 to 17) captured flies from the Sales Yards, Laboratory and City Dump and three placed at the State Industrial School (Station 62), 700 yards beyond the eastern limits of the city, captured flies from all points during a period of eleven days (August 9 to 20). These illustrations are few in comparison to the data available, but have been purposely selected to cover all sections of the city, thus indicating the general distribution from each point of release.

The fact that the map shows the stations at which recaptures were made to be mainly grouped in certain sections is due to the fact that it was found necessary to discontinue the work somewhat earlier than planned. Consequently the portion of the city remaining unworked was covered very rapidly, but flies were captured at practically all stations. A consideration of the *areas* covered by these last settings gives further evidence of how generally the liberated flies were scattered. For example, traps were placed at stations 31, 32, 33, 34, 35, 36, 37 and 38 from August 10 to 12 and flies were recovered from all release points except the Laboratory. Placed again from August 12 to 14 flies were recovered from all points. Other areas show similar results.

It has previously been stated that the built-up portion of Miles City was about two square miles in area. For the present purpose we may consider that the Sales Yards was at one corner of a square containing the city which is essentially correct. A breeding ground under usual conditions is a center from which flies would normally spread equally in all directions given similar conditions. This would indicate that flies from a breeding ground may spread over eight square miles of territory, or by taking the longest radius encountered within city limits (2,333 yards) we would get an area of nearly five square miles, and again by taking the longest radius actually encountered (3,500 yards) we get a territory of more than twelve square miles.

These details are important as they indicate several facts of practical significance—(1) that, given sufficient time, a given lot of flies from a breeding ground will become quite evenly scattered over large areas, (2) that even in a city of considerable size, every person allowing flies to breed on his premises is maintaining a nuisance which directly concerns every other individual residing in the city, (3) they emphasize the importance of general coöperation in order to secure successful results in control work (the cleaning up of a few places here and there has little value), (4) they indicate the far-reaching effectiveness of intensively applied control measures as a means of securing general sanitary conditions.

Concerning Time of Dispersion and Numbers of Flies.—Due to the repeated lots of flies released and the several day intervals at which traps were collected, the data concerning time required to spread given distances has no great value. It does indicate some facts, however. By reviewing the data for dispersion from the Sales Yards, it is evident that flies from this release point spread over the entire city, within a period of two to three weeks. From this point 248,140 flies were released. The Laboratory release point, on the other hand, represents only 35,270 house-flies and is comparable

to a very small breeding ground. In this case the period for the flies to become generally distributed is slightly longer according to the data, but probably not as an actual fact. Distances of over a mile were noted within a five-day period.

The summer's results have suggested that, if it were possible to liberate varying quantities of flies at stated intervals during a long period of time and to have a large number of permanent recapture stations from which flies were collected at daily intervals, results could be secured of some importance from the standpoint of disease transmission. The stations should be equally spaced and divided into successive zones of 100 yards width. The data secured would concern the following points: the average length of life of a fly, the number of flies liberated, the number recaptured at each station, the number recaptured in zones (each 100 yards more distant from the point of liberation), the time required to reach given stations, and the time to reach given zones. This data would permit averages to be figured that would indicate the probable distribution of any given lot of flies at any given time after liberation. Knowing then the length of life of any disease organism on the outside of a fly or in its intestine, it would be possible to establish a theoretical limit to which flies would be likely to carry virulent organisms from any point of contamination. Also, if at any given station the number of flies captured was in excess of the theoretical number expected, it would imply that this excess was explainable by unusual attractiveness or some other cause and hence would indicate the character of places at which the probabilities of contagion would be greatest.

Conclusion

The writer wishes to emphasize the fact that he by no means considers the preceding discussion to be any more than an addition to previous knowledge of fly dispersion. The suggestion that the stimuli emanating from breeding and feeding areas are the factors mainly responsible for seasonal dispersion under city conditions finds considerable support in the data presented and is not at variance with data previously published. It harmonizes better than any other suggestion with conditions as studied in the cities and towns of Montana and finds some support in the known habits and life history of the house-fly.

In spite of the fact that the number of flies used was greatly in excess of that of all previous experiments combined, it is felt that far larger numbers could be used to great advantage. Much remains to be learned concerning fly dispersion under various conditions and whatever evidence can be found to support different view points, the

final word, nevertheless, cannot be spoken until incontrovertible evidence has been gleaned from further experimental work.

Summary of Data and Results

General Summary

1. In a city, the built-up portion of which was about one and one-half miles square, 387,877 marked flies were liberated from four release points. The release points were so located as to give an idea of the possible spread of flies from breeding areas variously situated in relation to the city as a whole and each representing different conditions.

2. A total of 1,056 flies were recaptured at seventy-eight stations which varied from 50 to 3,500 yards from the point of release. This was the greatest distance at which recaptures were attempted.

3. The results indicated that under conditions which are favorable flies may spread from any given breeding ground to all parts of a city, even one of considerable size. Also that they may not only cross a city offering abundant feeding and breeding areas, but may even leave it and cross open country to points considerable distances beyond its limits.

4. The full possibilities of dispersion were not determined due to the relatively small size of the city, but the fact that flies spread from release points on one border to points on the opposite side indicates a possible radius of 2,333 yards (one and one-third miles) and that flies even traversed the entire city and crossed open country to points beyond justifies the belief in a still greater radius. The actual territory over which flies were recovered in the city was about two square miles, but possible dispersion over a territory of from five to more than twelve square miles was indicated.

5. While the results of this investigation are of general application to Montana cities and towns, it is problematical to attempt to apply them to more thickly populated areas where sanitary measures are more easily and more generally applied. Control measures mean fewer flies and fewer feeding and breeding areas, but does this mean a larger or a smaller radius of dispersion for what flies there may be?

Summary of Deductive Results

1. House-fly dispersion (the spread of house-flies from their breeding grounds and the factors controlling it) may be considered as a problem concerning short periods of time or as one of seasonal significance.

2. The factors which control dispersion are mainly, if not entirely, external stimuli. As regards their effect on the radius of distribution, these stimuli may be termed, *inciting* (*e. g.*, odors from feeding and

breeding grounds) or *inhibiting* (*e. g.*, low temperature, rain). Inciting stimuli give rise to tropic reactions, movements to and from, and consequently have a direct effect on distribution. Inhibiting stimuli indirectly affect distribution, because of resulting periods of inactivity on the part of the fly.

3. These stimuli, both inciting and inhibiting, form a complex set of external forces, each of which varies in intensity and duration.

4. The adult life of the house-fly is essentially devoted to two purposes, feeding and reproduction. Hence, it is evident that when dispersion is considered as a problem of long periods or of seasonal duration, that the stimuli from feeding and breeding areas are those of the inciting stimuli which act most continuously and for the greatest portion of a fly life and are the most important ones to control. Temperature is a constantly present stimulus, but may be inciting or inhibiting.

5. When dispersion is considered for short intervals other stimuli than those from feeding and breeding areas may assume greater importance. These stimuli may be inciting or inhibiting and under normal conditions have but minor significance as seasonal factors. Cities or localities undoubtedly occur, however, in which unusual physical or meteorological conditions are present with but slightly varying intensity during a complete season and consequently what would ordinarily be a stimulus of minor importance may become one of major seasonal importance (*e. g.*, strong wind blowing constantly from some direction, long continued rain, etc.).

6. By conducting dispersion experiments with a sufficiently large number of flies for a sufficiently long time and by covering a sufficiently large territory it seems likely that a limit for fly dispersion, under city conditions, could be determined which would be of more or less general application. The length of time would have to be at least equal to that of the average length of house-fly life.

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Explanation of Plates 24—26

Fig. 1. Showing approximate location of Sales Yards release point (x). Miles City beyond trees in background.
Fig. 2. Looking toward Miles City from Sales Yards release point.
Fig. 3. Looking toward Miles City from vicinity of release point on prairie one mile west of city.
Fig. 4. City Park which is between the river bed of Figure 2 and Miles City.
Fig. 5. Character of the country between Laboratory and State Industrial School (x).
Fig. 6. Release point—City Dump.
Fig. 7. Part of the Miles City horse sales yards.
Fig. 8. Privy (x) and manure pile (o) near Station 216.
Fig. 9. Privy with open vault near door to Station 216.
Fig. 10. Laboratory (x) and city in background.
Fig. 11. Trap used at Sales Yards (Station 168).

SOME OBSERVATIONS ON THE BREEDING HABITS OF THE COMMON HOUSE-FLY (MUSCA DOMESTICA LINNÆUS)

By Arthur T. Evans

During the past summer a number of experiments were conducted by the writer relative to the breeding habits of the common house-fly, *Musca domestica*. It is a somewhat popular belief that the house-fly is able to and does breed abundantly in garbage, manure and any other rubbish which may be accessible. As definite records on the breeding places of this fly were somewhat limited it was decided that a thorough search should be made of numbers of garbage cans, manure piles and any rubbish heaps that were found available to see if the larvæ could actually be found in these various conditions. The garbage cans examined contained many kinds of garbage in various stages of decay. With a single exception no larvæ of the house-fly were found in the cans examined. The larvæ as well as the adults of the small fruit-fly, *Drosophila* sp., appeared abundant in almost every can examined. Upon opening a garbage pail the adults of this insect usually fly out in numbers. It may be due to this fact that it is so generally believed


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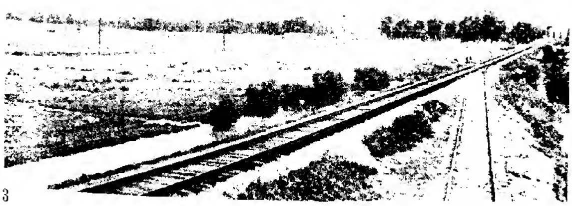
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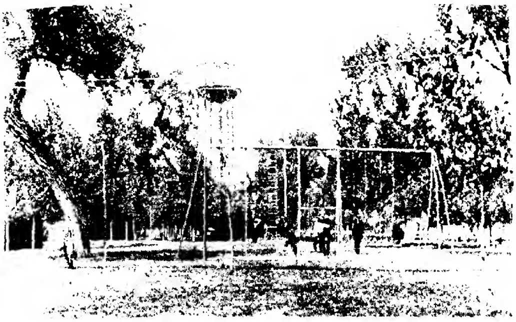

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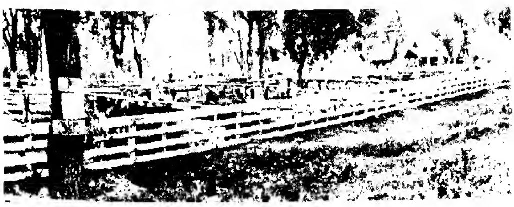

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that the house-fly breeds there, the adults of *Drosophila* being taken, by those who do not know, to be the young of the house-fly. Manure piles in the vicinity of the garbage cans studied were examined when possible and in every case the house-fly in all of its stages was found to be abundant. In the examination of manure piles the pupæ as well as the larvæ about to pupate were most abundant about the outer edge of the piles, in the loose straw or even in the earth. In one case where the manure was thrown into a low wagon the larvæ migrated to the bottom of the wagon box, where they fell through the cracks and buried themselves in the top layer of earth preparatory to pupation. Migration of the larvæ of the house-fly has been studied by various writers (1) and is recorded here merely as additional facts observed.

Another point noticed was that the larvæ avoided the deeper parts of the piles which were wetter from the seepage of moisture from the upper layers. This will be more fully discussed under the reaction of larvæ to moisture.

Although no larvæ were found in the rubbish examined not enough was studied to warrant forming an opinion. By rubbish is meant any trash other than that which might be classified as garbage or manure. The manure studied in all cases where not otherwise mentioned was the refuse from barns where horses were quartered.

The lack of the larvæ of the house-fly in garbage together with its abundance in stable manure seemed to indicate that there was some difference between the two substances which in the case of the manure furnished an optimum condition for fly breeding and was prohibitory in the case of the garbage. A chemical difference seemed the logical one to assume. Since the substance which was prohibitory in the garbage might prove to be a good larvicide an effort was made to determine it if possible. Quantities of garbage and stable manure were brought into the laboratory for study. When tested the manure was found to be alkaline while the garbage was acid. As ammonia is known to be present in manure several tests were made to determine the relative amount present. The tests showed the amount to vary with the length of time that the manure had been standing. Manure which had been standing no longer than thirty minutes was found to contain .647 of a per cent. That which had been standing for a longer period contained less; even as little as .314 of a per cent.[1] In cases

[1] These tests were made in the chemical laboratory of the University of Colorado. The writer is indebted to Professor Harry Curtis for the privileges of the laboratory as well as suggestions as to methods. I wish also to acknowledge the following assistance: Professor T. D. A. Cockerell for several important references as well as his kindly interest in the work; Professor A. H. Peebles for the loan of a book; and Professor Francis Ramaley for reading the paper for me.

where the manure had been standing for any considerable length of time it is quite certain that some of the ammonia passes off into the air. With all of the manure examined there was mixed more or less urine. No manure which had been standing for more than a day was tested as it was known that flies do not lay their eggs in such if fresh manure is present. The juice was extracted from a quantity of garbage to test relatively its acidity. The complexity of garbage indicates that a number of acids are usually present, these probably varying with the substances which are placed in the garbage can. No effort was made to determine the acids which were present in any can as this undoubtedly would vary with each can. It suffices to say that there were enough acids present to neutralize an equal amount of ammonia of a strength of .653 of a per cent. This per cent was found to vary with the staleness or freshness of the material in the can. In no case was acid found to be absent from garbage if it had stood for some time and was rotten.

After having found the relative amounts of alkali in manure and acid in garbage a number of experiments were conducted to determine if possible the maximum amounts of either of these substances which the house-fly might be able to breed in. A quantity of manure was brought into the laboratory and leached out with distilled water. When thoroughly washed the remaining solid material was pressed until all of the water possible was removed. A portion of this material was placed in each of six bottles. Enough ammonia was added to moisten well but not saturate the material. The ammonia varied in strength in the case of each bottle, the actual strengths being as follows: bottle 1, .001 per cent; bottle 2, .05 per cent; bottle 3, .1 per cent; bottle 4, .7 per cent; bottle 5, 1.4 per cent; and bottle 6, 2.1 per cent. A similar series of bottles was arranged with the difference that hydrochloric acid was added to the manure instead of ammonia. The strengths used in the various bottles were: bottle 1, .001 per cent; bottle 2, .025 per cent; bottle 3, .05 per cent; bottle 4, .1 per cent; and bottle 5, .561 per cent. In each bottle of both series was placed a mass of eggs which had been laid by flies kept in confinement with meat. Each bottle was then corked to prevent the escape of its contents.

After standing for several days in the laboratory the following observations were made: bottles 1, 2, 3 and 4 of the alkaline series contained a large number of larvæ. In bottle 5 but two larvæ had hatched. In bottle 6 but one had appeared. In both these last named bottles numbers of eggs had not hatched. No effort was made to determine whether all of the eggs had hatched in the other bottles as the number of larvæ present indicated that a large percentage had. The larvæ in this series pupated and metamorphosed into adults in a regular

manner except in bottles 5 and 6 where they wandered about a great deal, appearing restless. From these observations it appears that the highest amount of ammonia that the house-fly is able to breed in successfully lies between .7 per cent and 1.4 per cent.

An examination of the acid series showed that the eggs had hatched in only bottles 1 and 2. Bottle 1 contained three larvæ while bottle 2 contained but one. All of these larvæ left the manure and crawled about the sides of the bottles. None of the eggs had hatched in the other bottles.

Another series of experiments similar to those conducted on the eggs was carried out using larvæ instead. A number of the larvæ were placed in each bottle of the acid and alkaline series and were found immediately to bury themselves in the moistened manure. The next morning a number of the larvæ in bottles 5 and 6 of the alkaline series were found to be dead. The rest had left the manure to crawl about the sides of the bottles. Later a single larva in bottle 6 pupated. The larvæ in the other four bottles remained buried in the manure and a few days later had pupated. These metamorphosed into adults in a regular manner. The larvæ remained buried in the acid series for a short time, when they left the manure to crawl restlessly about the bottles in which they were confined. Those in the higher percentages of acid died on the second day; those in the lower percentages lived for some time but eventually died. None were found to have pupated in the acid series.

Only three experiments were conducted with the pupæ. A number of pupæ had been found to metamorphose regularly from alkali during the course of the other experiments so it was not thought necessary to test their resistance for more than the higher strengths. This was also done for acid as well as distilled water. Large numbers of pupæ when placed in earth which had been moistened with distilled water, .75 per cent acid or 2.1 per cent ammonia, were found to metamorphose seemingly without inhibition. This probably indicates that the pupæ are insensible to substances which may be larvicides. The tough coat of the pupa undoubtedly serves as a good protection. Earth was used in these experiments instead of manure as the larvæ are known to pupate in earth when possible.

An attempt was made to get flies to breed in garbage by confining them with it but in no case were they found ever to lay their eggs when so confined. Manure which had been leached out was moistened with the juice of garbage and a number of flies placed with it but all efforts to get them to breed in it failed. When larvæ were placed with such manure they left it soon and crawled about the containing

vessel. Although the garbage juice was not tested as to strength it was known to be acid.

In all of the work done thus far the eggs as well as the larvæ seem unable to develop in acid media, but up to a certain percentage they were found to develop in alkaline media. Tests indicated that acid has strong larvicidal properties. To determine this with more certainty a number of experiments were undertaken. A quantity of fresh horse manure which flies were known not to have laid their eggs upon was secured. Three portions of this were taken, each containing about a quart of solid manure. The first portion was confined under a bell jar with two flies. This manure was untreated. The second portion was confined under a bell jar with twelve flies. This manure was sprayed with a .75 per cent solution of hydrochloric acid. The third portion was divided into four smaller parts. On each of these parts was put a mass of eggs. The whole was then sprayed with a .75 per cent solution of hydrochloric acid. The parts were then confined in bottles. All of the cultures were examined from time to time for several days. The results observed were as follows: portion 1, which had not been treated, was found to contain great numbers of larvæ. The second portion, which had been sprayed and confined with twelve flies, contained but four larvæ. The third portion, which after being sprayed and impregnated with eggs had been divided among four bottles, was found to have developed larvæ in only one bottle and then only in small numbers. The larvæ were tiny and had left the manure to crawl about the bottle. Some, however, were unable to get out of the manure and had died. Manure which was well infested with both larvæ and eggs was sprayed with .75 per cent hydrochloric acid and placed under a bell jar. At the end of three days many of the larvæ were dead and many of the masses of eggs had not hatched, due to their being killed by the acid. Larvæ which were not dead had left the manure. Whether any great number of the eggs had hatched is doubtful, although no effort was made to determine this. It is quite probable that eggs just ready to hatch might finish the process even if treated with acid in this way, although the escape of larvæ from the manure would be difficult. Many would probably die before they could get out of it. Any remaining in the manure would certainly perish.

Old rags have been more or less discussed, especially by popular writers, as a favorable situation in which flies would breed. A number of rags were moistened and placed with a few flies beneath a bell jar. The flies were found to deposit their eggs upon them and in a few days the eggs hatched. As the rags were relatively clean the larvæ were unable to get food, so soon left them. Dr. Hewitt has found (2) flies

feeding in old rags which had been fouled with excreta. The excreta in this case probably furnished enough food for the development of the larvæ. It seems quite probable that flies might lay directly in rags under such conditions but the writer does not believe that flies will lay eggs in rags which do not contain a food supply. Without a food supply the larvæ would have to migrate or perish. It is very unlikely that flies would lay eggs where food would not be plentiful for the larvæ, especially with food so abundant as it is during the summer. Migration from a breeding place without food to a food supply would undoubtedly result in the death of many larvae unless the food supply was very close; in which case the eggs would very likely be deposited in the food supply when laid.

During the course of the various experiments it was noticed that the larvæ were especially sensitive to an excess of moisture. If too much of the solutions was added to the media the larvæ invariably would leave the media and go into a drier portion of the vessel. This was also noticed in the examination of the wetter portions of manure piles and especially the deeper, wet portions of bins. Although most of the bins examined were found to be faulty in construction so that many flies could gain access, yet the number of larvæ present were few. They were found to be prevented from breeding in the upper layers due to a layer of mold which developed over the top of the manure after it had stood for a short time in the bin. Its excellent development here is probably due to the constant temperature furnished by the fermenting of the manure below. Cow dung as dropped in the pasture was examined, as it was known to be saturated. No larvæ were found in the manure but they were sometimes present in the layer of earth just beneath the manure. The eggs were found to be deposited at the base of the pile near the ground into which the larvæ were able to enter soon after hatching. In this position beneath the pile the larvæ are kept supplied with food which seeps down from the pile above. The very few larvæ in cow manure indicate that it is not one of the favorable places for fly breeding. This probably is due largely to the amount of moisture that it contains as well as the compact form in which it is found.

Very little of the work which has been done on the fly deals with its relationship to garbage. During the summer months this is one of the problems of every city. Hundreds of flies swarm about exposed garbage. Their mission seems to be one of feeding rather than breeding. If one examines the manure heaps during the summer even more flies are found to be present. This is their real breeding place. Only one garbage pail was found during this work which contained larvæ. This contained a quantity of sardines and was teeming with maggots.

When tested it was found to be neutral. The presence of acid in garbage cans where the larvæ do not occur seems to indicate that it is the prohibitory factor. Paine (3) found the larvæ of the house-fly abundant in garbage pails but no observations seem to have been made as to the reaction of the contents of the pails which contained them. Observations carried out under the supervision of Forbes (4) in 1908 and 1909 have shown that flies may breed in a great variety of substances. In studying over the list from which larvæ were recorded in these observations, it is interesting to note the small number of larvæ taken from material which often goes to make up garbage. Materials which contained but a single larvæ are: rotten cabbage stump, banana peelings, cooked peas, and seepage from garbage pile. Other substances which might form a part of the contents of any garbage can with the number of larvæ each contained are: rotten bread and cake, 8; rotten watermelon and muskmelon, 14; rotten potato peelings, 12; old garbage, city dump, 15; rotten carrots and cucumbers, 23. Kitchen slop and offal was recorded as producing 193 larvæ. According to the experiments recorded in Forbes' paper this latter might be prohibitory to house-flies in two ways. It might be wet as the name would indicate that it was, or it might be acid. If it was wet to saturation and the larvæ were found in it, then the results are the exact opposite to those which I have obtained. It is quite possible that flies are able to breed in fresh garbage before it has had time to rot or become contaminated with any that has already rotted. Again, large pieces of any substance may furnish a breeding place for a number of flies. A mixture of the contents of the can when fresh garbage is added would undoubtedly prevent the laying of eggs upon fresh garbage by flies. In all of the cases where garbage was used in these experiments no large pieces of any one substance were taken. The garbage taken was in a rotten condition and was so thoroughly mixed that the substances which made it up could not be identified.

Manure or garbage sprayed with an acid of a strength of .75 of one percent would undoubtedly be unfit as a breeding place for flies. The dilution here suggested is so great that the cost would be very little if "commercial" hydrochloric acid were used. This acid which was used successfully in these experiments, when used in such dilute proportions would very likely not destroy the value of manure as a fertilizer. Undoubtedly any other acid would prove as good a larvicide. Although the spraying of open piles was not attempted owing to the lateness in the summer, it is believed that an acid spray could be used with good chances of success.

Summary

1. With one exception house-flies have not been found breeding in garbage. In this case the garbage was neutral. Their presence about garbage cans is for feeding purposes.

2. The eggs and larvæ were able to develop in manure wet with ammonia up to .7 per cent in a seemingly regular manner. Above this per cent their development is more or less inhibited.

3. The development of eggs and larvae was found to be inhibited in all strengths of hydrochloric acid.

4. The pupæ metamorphose regularly from both acid and alkali which is prohibitory to the eggs and larvæ.

5. Spraying of manure containing eggs and larvæ prevents to a great extent their further development. When manure is sprayed it prevents largely the deposition of eggs.

6 House-fly larvæ were not found living in the body of cow droppings. They were found in small numbers in the layer of earth just below the pile.

7. The larvæ were found to be sensitive to moisture in large quantities. When a medium was too wet they were found to leave it in a manner quite similar to their reaction in the case of acid.

8. Manure stored in bins was found not to be a good place for the breeding of flies due to the growth of mold which is usually found on top and also to the wet condition of the manure deeper down.

9. Hydrochloric acid was found to be an effective larvicide.

In an interesting paper (5) which has appeared since the completion of this work, M. E. Roubaud working in the military camps of the French army found that he was able to destroy the larvæ of the domestic fly by merely turning the inner parts of the pile over the fresh manure which contains larvæ. He finds that the heat generated by the manure as well as the gases which are formed during fermentation are very fatal to the larvæ when they are exposed to them. At 50 C. the larvæ are killed in three minutes; at 51 C. in one minute; at 59 C. in five to seven seconds; and at 60 C. in from four to five seconds. He has found that the middle of a manure pile may develop a heat of from 70 to 90 C. He also finds that flies do not breed to any extent in garbage. It seems justifiable to think that this developed heat may be the cause of so few larvæ in the center of the manure piles examined during the course of the work, reported by the present writer; it may also account for their not breeding well in manure bins. Roubaud does not state why flies do not breed well in garbage.

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PROFESSOR GOSSARD'S THEORY ON FIREBLIGHT TRANSMISSION

By E. F. Phillips, *Bureau of Entomology, U. S. Dept. of Agriculture*

In the February number of the Journal, there appears a paper[1] which Professor Gossard read at the Columbus meeting. Without presuming to know anything about fireblight or of the distribution of the causal organisms, it seems justifiable to examine the validity of his conclusions. If the hive does serve as a distributing center of the organisms, the fact will be accepted when adequate proof is presented, but in the meantime an attempt to point out the fallacies in the theory will only help to arrive at the truth. Although the author says "it must be remembered that this surmise, as yet, rests upon inference only," attention should be called to the total lack of experimental data to support the surmise.

The proof presented by Professor Gossard is as follows:

1. *Bacillus amylovorus* was not found in old honey from three hives in the spring. It is not shown that blight is carried over in that way.

2. *Bacillus amylovorus* was not found in fresh apple honey in five hives, from one of which the bees certainly worked on blighted blossoms.

3. *Bacillus amylovorus* lived in artificially inoculated sterilized honey up to 43 hours and 25 minutes and, when cultures from these were injected into apple twigs, blight usually resulted in 100 per cent

[1] Gossard, H. A., 1916. Is the hive a center for distributing fireblight? Is Aphid honeydew a medium for spreading blight? Jr. Econ. Ent. IX, 1, pp. 59–62.

of cases. The method of sterilizing and its action on the honey are not specified, although these may be of vital importance.

4. *Bacillus amylovorus* lived in artificially inoculated unsterilized honey in one case 47 hours and when this honey was injected into twigs, blight resulted in 52 per cent of cases.

5. The longer the time the organisms remained in unsterilized honey, the less the percentage of resulting infection. It is indicated that these organisms ultimately died in honey but the data are not presented on this point.

6. There is no evidence of growth of the organisms in honey. However, the author speculates that they may grow.

According to the evidence presented, there is no proof that the bacteria even enter the hive. No person will be inclined to deny the possibility that they do, but so long as all proof is lacking for the theory that the hive is a distribution center, we are justified in refusing to accept it. The fact that the organisms lived in honey for a time and then died is interesting, but the value of these facts as support for the theory is at best slight.

Since honeybees are often more abundant than other insects in the orchard during the blooming period and since a bee often visits dozens of blossoms on one trip and makes dozens of trips a day, it is only necessary to show that honeybees actually carry blight from flower to flower to account for a wholesale distribution. In the face of the evidence presented by Merrill (Jr. Ec. Ent. VIII, p. 402) that there is a relation between the number of green aphids and the amount of blight, it is evident that there is still room for investigations as to the office of the bee in this distribution. Waite showed that the honeybee can carry the blight organism from artificially inoculated blossoms on their mouthparts. What is now needed is additional evidence as to the relative importance of flying insects and piercing aphids in the transmission of the disease.

Gossard incorrectly assumes a rather general mixing up of the honey in the hive during the ripening process. The young bees of the hive do this work and the possibility that these bees will become field bees before the blooming period closes is most remote. While bees sometimes touch each other with their mouthparts, this is not sufficiently common to account for wholesale distribution of the organisms. Furthermore, nectar from fruit blossoms is usually consumed immediately and if not needed at once is ripened and stored in a few hours. The behavior of bees inside the hive seems to offer no support for the inferences drawn for this theory. It is pertinent to suggest the desirability of trying to isolate *Bacillus amylovorus* from the mouthparts of bees leaving the hive.

DETECTION OF ARSENIC IN BEES[1]

By E. B. Holland

The high periodical mortality in numerous apiaries of the state during the past few years has led to the examination in the Station laboratory of many samples of bees and of comb submitted by the Station apiarist. As a rule, little information was obtainable except that a large percentage of a colony or colonies had died within two or three days. Disease was not considered the cause of death as no disease of the adult bee has as yet been recognized. On the other hand, the old theory of poisoning, so often advanced as a solution of like problems, appeared more plausible than usual in view of the fact that spraying with arsenate of lead or with Paris green has become the general practice of farmers, horticulturists and tree wardens for protection against leaf-eating insects. Furthermore, bees obtain pollen and nectar from a large number of "honey" plants over an area of approximately a dozen square miles (two mile radius)[2] and are very active during the spraying season. Bees, therefore, must be particularly liable to injury if arsenical or other "stomach poison" insecticides are used in the vicinity. The above assumption was substantiated in a large measure by chemical examination. A small amount of arsenic was found in 12 samples out of 23 submitted, as shown by the following table. The detection of arsenic in stored pollen was of special interest.

Results of Analyses

	Arsenic Present	Possible Trace	No Arsenic	Total
Bees	10	2	6	18
Comb	2	1	2	5
Percentage	52	13	35	100

At least 10 grams of material are deemed necessary for satisfactory work. Considerable labor is involved, however, in collecting that number of bees free from dirt and litter. As the amounts employed varied from 40 grams to less than 2, the tests are not strictly comparable. Moreover, the percentage of reacting samples was substantially reduced by including several lots secured in the course of the work that were not even suspected of poisoning.

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[1] Published with the approval of the Director of the Massachusetts Agricultural Experiment Station.

[2] According to J. L. Byard, superintendent of the College apiary.

Methods for Destroying the Organic Matter

At the outset the organic matter in the samples was destroyed with sulfuric and nitric acids. These agents were first suggested to the writer by the late Dr. Goessmann in place of hydrochloric acid and potassium chlorate formerly employed for the purpose in the station laboratory. The process requires time and patience to insure *complete* destruction of the organic matter but is satisfactory as a whole and preferable to the old method.

As the number of samples increased and the demand for an early report became more urgent, an effort was made to improvise a process to meet those conditions with the least possible interference with regular work. An attempt at treating with potassium chlorate and igniting (an old method for wall paper) proved impracticable, and hydrogen peroxide proved inefficient as an oxidizer. Sodium peroxide, potassium bichromate and potassium permanganate were also considered. The last appeared the most promising and could be used readily as a saturated solution. The combined winter losses of two apiaries furnished a liberal supply of bees for experimental work.

Method Employed

Representative portions of the bees as received and with an added amount of arsenous oxide or of arsenic oxide were macerated in a platinum dish with a saturated permanganate solution (20 c.c. to each gram of material), evaporated to dryness, heated at a temperature not exceeding faint redness, pulverized and reheated until the residue would no longer "glow." The "crude" ash was transferred to a Marsh apparatus with sulfuric acid (1–3) and gave, in cases of added arsenic, a positive inside mirror. Several samples of suspected hay also reacted with the above test; evidently due to heedlesss spraying of the grass. Possibly permanganate has been used in this connection by other workers as it is now employed for many oxidizing purposes in most laboratories. Nevertheless, our method of procedure together with results secured are offered in the hope that they may prove of service.

Toxic Dose of Arsenic for Bees

So far as noted there have been no reliable data published as to the toxic dose of arsenic for bees. The arsenical compounds generally employed as insecticides are salts of lead, copper and lime. Although lead and copper have toxic properties, arsenic should be considered the active principle of the insecticide. Practical experience indicates that a given weight of arsenic (As) in the form of arsenites (As_2O_3) is more poisonous than in arsenates (As_2O_5). This appears to hold true

in relation to plant as well as animal life. While no positive statements are possible owing to lack of sufficient data, 65 milligrams of arsenous oxide (white arsenic) to 1,000 grams of live weight may approximate the toxic dose[1] for the horse, ox, sheep and fowl, and 9 milligrams for the dog and pig. On the former basis of susceptibility, 65 milligrams of arsenous oxide (equivalent chemically to 76 milligrams of As_2O_5) would kill 1,000 grams (net weight) of bees or 12,658 individual workers[2] weighing 79 milligrams each, or on the latter basis of susceptibility, 9 milligrams of arsenous oxide would accomplish the same results. The toxic dose for bees is unquestionably small, whatever the figure, as a considerable portion of the arsenic detected in the samples was evidently in the bee load and not assimilated as shown by the following treatment. A lot of bees containing arsenic, after being shaken with 1 per cent nitric acid for 1 minute and rinsed twice with water, gave only a "possible trace" of arsenic. Another portion treated similarly with 3 per cent nitric acid would no longer react. The use of 3 per cent acid proved inadvisable, however, as it was found too active for even so short a period. The above test would indicate that bees are susceptible to even less arsenic than is detected in the original samples.

The work will be continued during the coming season with a view of determining the amount of arsenic present.

INJURY TO PEANUTS BY THE TWELVE-SPOTTED CUCUMBER BEETLE[3]

(Diabrotica 12-punctata Ol.)

By David E. Fink, *Entomological Assistant, Truck Crop and Stored Product Insect Investigations*

Introduction

The adult of the twelve-spotted cucumber beetle (*Diabrotica 12-punctata* Ol.) is well-known as nearly omnivorous in its feeding habits, and in Tidewater Virginia, occurs on practically all truck crops. Because of this omnivorous habit, their injury to any one particular truck crop is sometimes nearly negligible, except at intervals when few crops are in the fields. The larvæ of this species are also well

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[1] Calculated from data cited by Nunn, Veterinary Toxicology.

[2] Workers containing little or no feces average about 79 milligrams in weight: on leaving the hive in the morning during the active season the feces may constitute an additional 25 milligrams; a load of honey varies from 22 milligrams to several times that weight. From various references furnished by Dr. B. N. Gates of this Station.

[4] Published by permission of the Secretary of Agriculture.

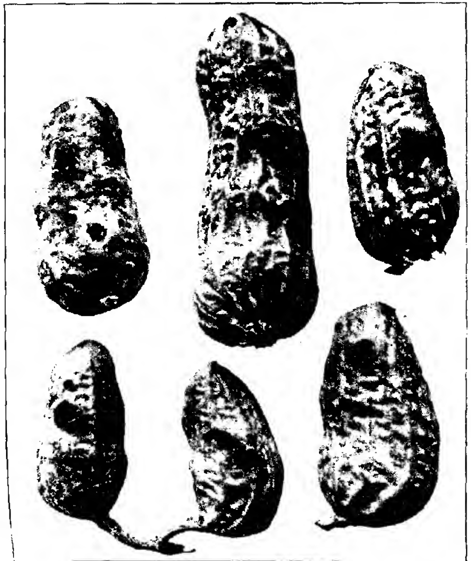

Fig. 1

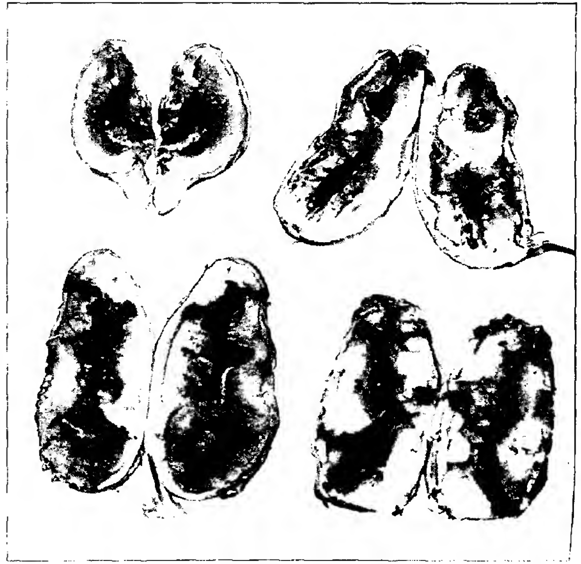

Fig. 2

known, at times, to seriously injure truck and other crops by feeding on the roots. Particularly is this the case with a growing crop like corn, that occupies the land for a comparatively long time.

Since 1908,[1] and especially for the past three years, peanuts, which were hitherto considered to be free from insect attack, were observed to be injured by larvæ boring into the pods just as they were beginning to form, and afterwards almost entirely destroying the contents by feeding on the interior tissues. During the years 1913 and 1914, owing to the few larvæ then actually found in the pods, no attempt was made to rear the adult. In the summer of 1915, however, the injury to peanut pods was observed to be extensive, and larvæ comparatively abundant with the result that the reared adults were determined as *Diabrotica 12-punctata* Ol.

Nature and Extent of Injury

At the Virginia Truck Crop Experiment Station, Norfolk, Va., two plats—each about a third of an acre in size—are used experimentally for the growing of peanuts. Plat 1 is used exclusively for peanuts. In plat 2, peanuts are used in rotation with corn and potatoes, once in three years. At intervals during the months of August and September, 1915, peanut plants were dug from both plats, and the pods were carefully examined to determine the extent and nature of the injury. Observations made at the time indicated that the younger and softer pods were usually the most seriously injured. The number of holes found in a pod varied from one to three or more, but rarely was more than one larva found in a single pod. The larvæ attack the pods at various places appearing, however, to favor the free end. After gaining entrance to the interior, the larva feeds on the contents. In more matured pods their work becomes more detailed by tunnelling through the kernels. Injured pods when cut longitudinally clearly show this condition (see Pl. 27, Fig. 2).

In many instances young larvæ gain entrance to pods in which the rate of growth is proportionally greater than the growth of the larvæ. As the food contents soon become too hard, the larvæ invariably leave such pods to enter others. Matured peanut pods, as a rule, are seldom observed injured, although the exterior of such pods

[1] Observations were conducted on this larva on peanuts that year by Messrs. C. H. Popenoe and F. H. Chittenden, and the following year by Mr. E. G. Smyth.

Explanation of Plate 27

Fig. 1. Peanut pod showing entrance and exit holes made by the larvae of the twelve-spotted cucumber beetle (*Diabrotica 12-punctata*).

Fig. 2. Peanut pods cut longitudinally to show the work of the larvae of the twelve-spotted cucumber beetle (*Diabrotica 12-punctata*.)

evidences many attempts to gain entrance. Growing plants in which the pods mature rapidly are less susceptible to larval injury, while plants that make vigorous vine growth but through some unknown cause fail to mature the pods rapidly, usually prove on examination to be vigorously attacked by the larvæ. In plants which have died as a result of disease, the pods are either free from larval injury, or indicate that they are less subject to such attacks. This tends to confirm the statement that rapidly maturing pods are seldom injured by the larvæ. In some instances nearly the entire crop of pods borne by a plant may be injured, while in others the proportion of injured to uninjured pods is about equal. On plat 1, where peanuts are grown each year, the pods indicate a greater percentage of larval infestation than on plat 2, where peanuts are grown in rotation with other crops.

The peanuts on both plats were harvested on October 18 and 19. In order to ascertain the percentage of infestation, a certain definite weight of peanut pods from both plats 1 and 2 was examined, and all pods that indicated larval injury were separated from the uninjured ones and their respective weights obtained.

The total weight of peanut pods examined from plat 1, was 15¼ pounds, this amount gave 8 pounds not injured to 7¼ pounds injured pods. The percentage, therefore, was 53 uninjured and 47 injured pods.

The total weight of peanut pods examined from plat 2, was 10½ pounds, this amount gave 8 pounds uninjured, and 2½ pounds injured pods. The percentage was, therefore, 76 uninjured and 24 injured pods.

Conclusion

From the above observations it is shown that peanut pods, particularly when still young and soft, are subject to serious injury by the larvæ of the twelve-spotted cucumber beetles (*Diabrotica 12-punctata*).

That plants in which the pods are matured or maturing rapidly are either free from, or decidedly less injured by the larvæ.

That rotation, and a vigorous growing crop are decided factors in controlling or keeping the crop free from the attack of the larvæ.

As alternates it is considered advisable to cease growing all cereal crops, particularly corn, when rotating with peanuts. Cowpeas, clover, potato, cabbage, spinach, kale, turnips, tobacco, and eggplants are, so far as known, not subject to larval injury.

Fig. 1

A COCCID-FEEDING MOTH

Holcocera iceryæella (Riley)
(*Blastobasis iceryæella* Riley)

By E. O. Essig, *University of California, Berkeley, Cal.*

During the summer of 1915 the writer was able to make a number of observations on a coccid-feeding moth which occurs in considerable numbers on the campus of the University of California. This insect was sent to Dr. C. V. Riley who published a description and short report in 1886.[1] During the winter of 1914 Mr. E. P. Van Duzee of the Station Staff called attention to the small hibernating larvæ beneath the old shells of the European peach scale, *Lecanium persicæ* (Fab.). From these caterpillars adults were reared the following spring and forwarded to the Bureau of Entomology, United States Department of Agriculture, Washington, D. C., and were determined by Mr. August Busck.

The caterpillars are small, averaging about 6 mm., but some attain a length of 10 mm. The color is dark reddish-brown with the dorsum noticeably dusky or black. There are several conspicuous narrow whitish lines on the dorsum and the body is covered with numerous short irregular lines of the same color. The tubercles and hairs are also white. Pl. 28. fig. 2 shows the markings fairly well. The prothoracic shield and head are very dark brown or black. The moths average about 9 mm. to the tips of the wings, but the body is only about half as long. The color is ashy-gray due to a mingling of light and dark scales as shown in Pl. 28, fig. 1. Near the middle of the front wings the black scales form an oblique transverse line which is bordered anteriorly by a light-colored line of about the same width. The posterior portions are much darker than the remainder because of the presence of numerous larger black patches. The under surface of the front wings and all of the hind wings are light, the fringes being yellowish. The body is silvery-gray with the posterior part of the abdomen sometimes dusky. The legs and antennæ are light gray with dusky markings.

[1] Report of the Commissioner of Agriculture, pp. 484–486. 1886.

EXPLANATION OF PLATE 28

Fig. 1. Adult of *Holcocera iceryæella* (Riley). Enlarged. (Original. Photo by Dept. Scientific Illustration, Univ. of Cal.)

Fig. 2. Larvæ of *Holcocera iceryæella* (Riley). Enlarged. (Original.)

Fig. 3. Branch of laurel or sweet bay tree, *Laurus nobilis* Linn., showing infestation of greedy scale, *Aspidiotus camelliæ* Sign., and the webs of the larvæ of *Holcocera iceryæella* (Riley).

The exact food habits of the caterpillars are difficult to ascertain and the writer is not sure just how much of the diet consists of the old dead bodies, the waxy scales, etc., and how much of the living coccids. Dr. Riley records the black scale, *Saissetia oleæ* (Bern.) and the cottony cushion or fluted scale, *Icerya purchasi* Mask., as hosts. To this list may be added the European peach scale, *Lecanium persicæ* (Fab.), already referred to, the greedy scale, *Aspidiotus camelliæ* Sign., and Baker's mealy bug, *Pseudococcus bakeri* Essig. Large numbers of the caterpillars were taken from beneath the dead and living scales of the European peach scale and it was apparent that they were feeding upon the dead shells as well as upon the eggs and the young, but there was no evidence of their having devoured more than half-grown scales. The larvæ were found in the greatest numbers upon a laurel or sweet bay tree, *Laurus nobilis* Linn., which was severely infested with the greedy scale, but there was no evidence of their having served as a check to ravages of the scale.

Probably for protection the larvæ spin extensive webs into which are often incorporated bits of leaves, bud scales and other refuse. The webs are often quite compact and may be numerous enough to cover a considerable area. They are to be found in the forks of the limbs, leaf and bud axils, and in fact anywhere the scale insects abound in any considerable numbers. Within or beneath these webs the larvæ live and eventually pupate and do not ordinarily leave them except when one endeavors to remove them by force. They then wriggle exceedingly violently and often escape completely.

Mr. C. J. Pierson, a graduate student of the University succeeded in rearing a number of adults from caterpillars which were taken from the egg masses of Baker's mealy bug.

A HANDY FIELD AND LABORATORY BINOCULAR MAGNIFIER

By R. S. Woglum, *U. S. Bureau of Entomology*

Several years ago while visiting the eminent Coccidologist, Mr. E. Ernest Green, at the Royal Botanical Gardens, Peradeniya, Ceylon, the writer's attention was drawn to a simple binocular magnifier adapted for attaching over the eyes. The binocular shown in the accompanying illustration, which was secured from a firm in London, has proved of such value for the observation of insects under conditions requiring low magnification, both in the field as well as in the laboratory, that it has appeared advisable to bring it to the attention of others.

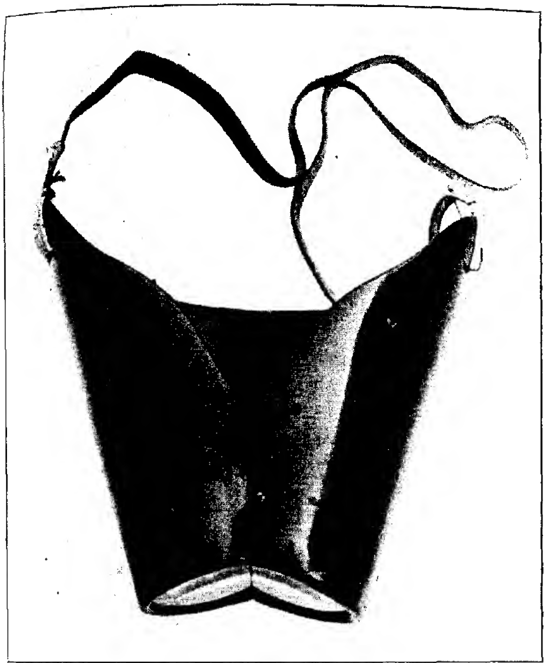

Fig. 20. A handy binocular

The magnification approximates that of the ordinary hand lens, but the flat field produces very little strain to the eyes even when used continuously for an hour or more. In counting or observing such small insects as Coccidæ, in examining plants and seeds, writing small labels, making fine drawings, and the like, the writer's experience has found this magnifier decidedly superior to a hand lens because it requires no manipulation, is less trying to the eyes, and enables the use of both hands.

NOTES ON PEGOMYIA HYOSCYAMI PANZ.[1]

By E. N. Cory, *College Park, Md.*

In 1912 the writer found a plant of lamb's-quarters infested by leaf-miners. These were turned over to Mr. A. B. Gahan for rearing. During the spring and early summer of that year additional miners were found by Mr. Gahan and the writer in lamb's-quarters and spinach. Adults were bred from these specimens and determined tentatively as *Pegomyia vicina* Lint. In 1914 the writer began rearing miners from *Chenopodium album,* continuing this work through 1915. A large series was secured by the end of that year.

Specimens of these were submitted to Mr. Knab, of the U. S. National Museum, who determined them as *Pegomyia hyoscyami* Panz., an European species not heretofore recorded from the United States, *Insecutor Inscitiae Menstruus,* Vol. 4, Nos. 1–3, p. 1.

Later upon working over the entire series of specimens reared by Mr. Gahan and the writer from spinach, *Chenopodium album* and *Amarantus retroflexus,* the conclusion was reached that they were all *Pegomyia hyoscyami* Panz.

Meanwhile Mr. Knab had submitted specimens from the series out of *Chenopodium album* to Dr. T. Villeneuve, France, who confirmed his determination of *Pegomyia hyoscyami* Panz.

P. Sorauer in "Handbuch der Pflanzenkrankheiten" places *P. hyoscyami, atriplicis* Gour., *betæ* Curt., *chenopodii* Rond., *conformis* Fall., *dissimilipes* Zett., *spinaciæ* Holmgr. and *vicina* Lint. in synonymy.

The identity of *Pegomyia hyoscyami* Panz. and *P. vicina* Lint. is given in Cameron's paper "A Contribution to a Knowledge of the Belladonna Leaf-miner, *Pegomyia hyoscyami* Panz. Its Life-History and Biology," *Annals of Applied Biology,* Vol. I, No. I, May 1914, pp. 43–77 inclusive.

In this paper Mr. Cameron places in synonymy *P. hyoscyami* Panz., *P. atriplicis* Gour., *P. chenopodii* Rond., *P. conformis* Fall., *P. cunicularis* Rond., *P. effordiens* Rond., *P. egens* Meig., *P. exilis* Meig., *P. gouraldi* R.-D., *P. hæmorrhoa* Panz., *P. betæ* Curt., *P. dissimilipes* Zett., *P. femoralis* Brischke., *P. spinacia* Holmgr. and *P. vicina* Lint.

Stein recognizes the light colored, *hyoscyami* Panz. as the true species and *betæ* Curt. as a darker variety. Several authors agree that the color of the flies depends to a large extent upon the kind and extent of the larval food.

Cameron suggests the possibility of "biologic" species within the

[1] Contribution from the Maryland Agricultural Experiment Station.

limits of a single polyphagous species. The fact that he was unable to get adults bred from belladonna to oviposit on mangold leaves and vice versa has led him to question the statement that insects often oviposit on a number of related plants. His experiments, showing a preferential selection of food plants, lead him to the belief that slight variations, such as in color, may arise from the adoption of preferences.

Flies bred from Chenopodiaceæ (*Spinacia oleracea* and *Chenopodium album*) and from Amarantaceæ (*Amarantus retroflexus*) do not show any differences in color that would warrant the separation of varieties, out of the series at hand.

The entire series bred by Mr. A. B. Gahan and the writer from the above named host plants has been carefully gone over by Mr. Knab. The specimens in the U. S. National Museum and two specimens from Wooster, Ohio, in the possession of Mr. Gahan, all labelled *P. vicina* Lint., have been compared with this series. Without doubt they are all the same species, *P. hyoscyami* Panz.

Seasonal History

The first record of eggs found is May 15, 1915. These eggs were on *Chenopodium album*. Three masses of 3, 4, and 4 eggs, respectively, were found.

Nearly full grown larvæ were found on May 17, 1912, in spinach leaves. These produced adults on June 5, 6, 7, 12, 15 and 19.

From May 15 to the first week in August the miners are readily found in lamb's-quarters. After that time they disappeared until September when a new brood appeared.

Repeated efforts to get the adults to breed in confinement have failed and so no definite records were obtainable on the number of broods. The straggling emergence of adults indicates a considerable overlapping of broods. However, there are certainly three broods during the season with a probability of the existence of at least one more brood.

The Egg

The egg is .72 mm. x .26 mm., nearly cylindrical, white and heavily reticulated. They are deposited in rather regular rows on the under surface of the leaves. The greatest number observed on a single leaf was eight. Generally three or four is the usual number. The time from the deposition of the egg to its hatching approximately is four days.

The Larva

The larva is nearly cylindrical in cross section. It tapers to the anterior end when stretched out, but in life the tapering is only slightly

noticeable. The heavily chitinized mouthparts are visible through the translucent glossy, greenish white integument. Length 6–7 mm. This stage requires 15 to 17 days. Three larval instars may be noted. The larvæ are capable of reëntering the leaves after being removed from their burrows. When the entire parenchymatous tissue of a leaf is consumed, before the larva reaches its full development, it migrates to another leaf.

The "rake" or "great hooks" consist of two arms attached to a bifid basal piece. The mandibular sclerites bear four teeth each (Fig. 21*a*).

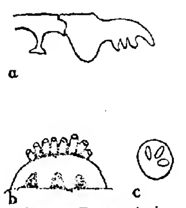

Fig. 21. *Pegomyia hyoscyami*, *a* great hooks, *b* anterior spiracle, *c* posterior stigmatal area

The anterior spiracles have eight lobes opening on the margins of a fan-shaped prominence (Fig. 21*b*).

The posterior stigmatal areas are rather widely separated and each spiracle bears three stigmata arranged as in Fig. 21*c*.

The structural details from the author's specimens agree exactly with the description of *P. hyoscyami* Panz. of Cameron but not with his figures and agree almost exactly with the Riley figures of *P. vicina* Lint., *Insect Life*, Vol. 7, p. 380.

The Puparium

The pupa is nearly cylindrical, obtusely rounded at both ends. Color light chestnut brown when first formed, changing to darker brown just before emergence. The anterior spiracles rise in fan shape from rounded rugose bases. The posterior spiracles are slightly raised on globular bases. Between the stigmatal areas are three heavy ridges converging ventrally. The longest pupal stage observed occupied 20 days, the shortest 14 days with all graduations in between these extremes.

The Adult

The adults bred here agree in all essentials with the descriptions of Stein, and Meade, as given by Lintner, with the correction noted by Sirrine in Bul. 99, N. Y. Agricultural Experiment Station.

The coloration varies in the series in individuals from the same host plant. There are no constant color changes in the series from different hosts.

The chief point of doubt as to the identity of specimens may be due to collapse of specimens killed too soon. Such specimens often have the frontal stripe obscured by the orbits becoming approximated; especially is this true in the males.

The entire life occupies 30 days as its shortest period. The longest period covered 42 days. An average of 32 days is correct for the majority of cases.

Parasites

The only parasite bred from *Pegomyia hyoscyami* Panz. is *Opius foveolatus* Ashm.[1] This species has been bred from nearly every lot of miners but never in sufficient numbers to indicate that it might be an important factor in the control of the miner.

Control

On weeds such as Chenopodium and Amarantus no effort has been made to control the miners and the miners have not appeared on spinach since 1912. In this connection it might be well, however, to cite the work of Vassiliev, "Report of the Work of the Experimental Entomological Station of the All-Russian Society of Sugar Refiners in 1913," Kiev. 1914; abstracts in *Review of Applied Entomology,* Vol. II, No. 7, Ser. A., p. 467. He has used a solution of barium chloride in 5, 6, and 7 per cent solutions with excellent control of the miners in beet leaves.

COST OF DUSTING AND SPRAYING A NEW YORK APPLE ORCHARD

By C. R. Crosby

There is very little information available in regard to the comparative cost of dusting and spraying an apple orchard under commercial conditions. On January 15, 1916, Mr. W. A. Crandall of Kendall, N. Y., read a paper before the Orleans County Fruit Growers' Association at Albion, N. Y., in which the following facts were presented. Mr. Crandall has an orchard of about twenty-one acres containing about 625 trees, ranging in age from thirty-five to forty years, mostly Baldwins, Russets and Greenings with a few odd varieties. This orchard was sprayed in 1913 and 1914 and dusted in 1915. The owner has kept a careful record of the expense as indicated in the following table. Each year three applications were made; the first when the blossoms showed pink, the second as the last of the petals were falling and the third in August.

[1] Determined by Mr. A. B. Gahan.

COST OF SPRAYING ORCHARD IN 1913

Time of Application	May 4	May 14	Aug. 14	Total	Cost
Gallons of spray material	1,400	5,000	2,200	8,600	$60 80
Man, hours	43.5	116.5	86	246	49 20
Horse, hours	26	73	84	183	23 79
Equipment, hours	26	73	84	183	20.05
					$153 84

In 1913 the crop was 1,183 barrels. The spray materials consisted of lime-sulfur and arsenate of lead.

COST OF SPRAYING ORCHARD IN 1914

Time of Application	May 19	May 26	Aug. 1.	Total	Cost
Gallons spray material	3,000	4,000	4,000	11,000	$64 80
Man, hours	85	90	99	274	54 80
Horse, hours	47	47	63	157	20.41
Equipment, hours	47	47	63	157	18 06
					$158 07

In 1914 the crop was 1,653 barrels. The spray material used consisted of lime-sulfur and arsenate of lead.

COST OF DUSTING ORCHARD IN 1915

Time of Application	May 4	May 19	Aug. 18	Total	Cost
Pounds of dust	670	885	475	2,030	$88 50
Man, hours	13.5	14	11.5	39	7 80
Horse, hours	13.5	15	11.5	40	5 20
Equipment, hours	13 5	15	11.5	40	4 60
					$106 10

In 1915 the crop was 885 barrels. The dust mixture used consisted of 90 per cent finely ground sulfur and 10 per cent arsenate of lead.

From the above tables it will be seen that the cost of dusting the orchard in 1915 was $47.74 less than the cost of spraying it in 1913, and $51.97 less than spraying it in 1914.

In 1915 the whole orchard was dusted and there was no opportunity of comparing the relative efficiency of the different methods of applying the materials. Extensive observations as to the relative efficiency of dusting and spraying have been published in bulletins 340, 354, and 369 of the Cornell University Agricultural Experiment Station.

Scientific Notes

An Egg Parasite of the Army-worm (*Heliophila unipuncta*). During the late spring of 1914 a severe outbreak of the army-worm (*Heliophila unipuncta*) occurred in many places in southern and central Illinois. Notwithstanding the fact that many of the worms were killed by insect enemies and diseases, large numbers completed their growth, and the moths were very abundant by the middle of June. During the latter part of June and the first part of July, careful watch was kept of grass-lands and lawns in the central part of Illinois for the appearance of the second generation of the worms, but only a very few were found.

In another part of the state, moths of this species were very abundant during the last two weeks of October, 1914. Thousands of them were seen in the early evenings around piles of cull apples in orchards, and in one case thirty-five were counted on a single rotten apple. In the spring of 1915, however, it was hard to find army-worms in this section; and it seemed probable that some egg-parasite might be keeping the species in check.

In the middle of July, 1915, army-worm moths again became abundant in the vicinity of Springfield, Ill., and on each of several evenings nearly a hundred were caught in a small fly-trap. July 24, six pairs of these moths were placed in a lantern-chimney cage over a six-inch pot containing a plant of crab-grass. July 26 this grass was found to be well stocked with eggs, and the adults were killed, the chimney was removed, and the pot containing the grass was set outside the insectary on a lawn where large numbers of army-worm moths had been noticed for several nights previous. The pot was left here until the morning of July 28, when several of the eggs were removed and placed in small shell-vials tightly stopped with cotton. August 3 several army-worms hatched, and August 13 a small Chalcid was noticed in one of the vials. On the next day a number of these Chalcids were seen emerging from the army-worm eggs; and an examination made several days later showed that 79 per cent of the eggs had been parasitized. A large series of experiments was at once started to determine the general abundance of this egg-parasite; but a little later all were accidentally destroyed.

Specimens of this Chalcid were identified by Mr. J. C. Crawford as belonging to the genus *Telenomus*, but whether or not they represent a new species he was not then prepared to say.

As the army-worm moth is nearly always common in the summer and fall months, it seems probable that this new egg-parasite may have a powerful influence in restricting the increase of this pest and in bringing sudden outbreaks to a conclusion.

Wesley P. Flint.

State Entomologist's Office, Urbana, Ill.,
March 30, 1916.

Cause of Death of a Valuable Animal During Fumigation with Nitrobenzene. At the Columbus meetings of the Association of Economic Entomologists, Professor William Moore presented a valuable and suggestive paper on the fumigation of animals with nitrobenzene, for the purpose of ridding them of their ecto-parasites.[1] On our return to Ithaca, Mr. W. L. Chandler and I decided to check over and use this method on the animals we were using in our laboratory work, and whenever opportunity arose.

In the course of the work, after many favorable experiments, a valuable hunting dog was being fumigated for fleas. In that respect the experiment was a great success for when I saw the dog nearly a half hour after he was exposed, the fleas were literally falling off from him. Less than an hour later he was dead, all attempts to

[1] Jour. Ec. Ent., Feb. 1916, IX, p. 71–78.

revive him having proved futile. Unfortunately for the completeness of the data, he was not under observation during this period. The fumigant had been used so frequently without any untoward results, both by Professor Moore and ourselves, that nothing of the sort was anticipated.

An autopsy was held, not only for the purpose of noting any possible effects of the gas but because we expected to find that the death of the animal was due to the bursting of a blood-vessel or similar injury, during some unnoted struggle. Nothing of the sort was found. In fact, there was not the slightest trace of inflammation which could have been attributed to the effect of the gas.

On the other hand, we found between the liver and the diaphragm, two specimens of the giant nematode, *Dioctophyme renale* (*Eustrongylus gigas*). The liver tissue in their immediate neighborhood was diseased, the entire inner face of the diaphragm was festooned with an organized exudate, and there was a general, acute peritonitis. Mr. Chandler and I shall present a more detailed report of these conditions elsewhere.

It is sufficient to say here that the real cause of the death of the animal was the presence of the parasites. Nevertheless, the experience served to emphasize what I pointed out at the time the paper was first presented. We need additional data regarding the effect of the gas under different physical conditions of the animals and even when that is known, we may have to allow for individual idiosyncrasies. For the present, experimenters may find it advisable to use less valuable animals than our victim.

WM. A. RILEY,
Cornell University.

Gonepteryx rhamni Linn. and Castnia therapon Koll. in New Jersey. *Gonepteryx rhamni* Linn. (Lep.). An almost perfect female of this species, known as the Brimstone Butterfly, was taken at Rutherford, N. J., during the early part of December, 1915, from a case of French shrubs. It had evidently emerged on the way over, probably only a short time before the box was unpacked, as it was in a fairly fresh condition. W. F. Kirby in "European Butterflies and Moths" states that "the butterfly abounds in and near woods in most parts of Europe, Asia and North Africa . . . common in the south of England . . . unknown in Scotland . . . and the only certain locality in Ireland is Killarney." Seitz, in "Macrolepidoptera of the World, Palearctic Butterflies," Vol. I, p. 60, figures a male and female and states that "it inhabits the whole Palearctic Region with the exception of most northern districts and the Canaries, occurring also in North India as a slightly modified local form." The larva feeds on buckthorn from May to July. The female found in the French stock was taken from a bundle of *Cotoneaster microphilla* which is also a thorny shrub. *Castnia therapon* Koll. (Lep.). During January, 1916, orchids growing in a greenhouse at Bound Brook, N. J., were found to be infested by a lepidopterous larva which bored through the rhizome and up into the bulb, doing, of course, considerable damage. The greenhouse man was interested enough to save two pupæ which he found in the infested plants, from which later emerged specimens of *Castnia therapon* Koll. (identified by Mr. F. E. Watson). A brief account of this insect together with a figure can be found in Seitz's Macrolepidoptera of the World (Vol. VI, p. 12, plate 7, a) which gives Brazil as its native home and *Oncidium crispum* and *Catasetum* sp., as food plants. An additional species of orchid can now be listed, namely *Cattleya labiata*, this being the plant found infested at Bound Brook. These orchids came originally from Pernambuco and were undoubtedly infested at the time of their arrival. This insect occurs also in other New Jersey orchid houses but in a very limited way.

HARRY B. WEISS,
New Brunswick, N. J.

Report of the Finding of American Foulbrood and European Foulbrood in the Same Bee Comb. In the examination of about five thousand suspected samples of bee comb and brood from every section of the United States and several foreign countries, the writer has never until recently observed both American foulbrood and European foulbrood in the same comb. The sample referred to is No. 4982, from Patterson, Stanislaus County, California, sent to the Bureau of Entomology by Mr. Willis Lynch, County Apiary Inspector, Stockton, California, and diagnosed in the Bureau Laboratory May 4, 1916.

The presence of American foulbrood is exhibited by many typical scales closely adhering to the lower cell wall and showing, on microscopical examination, numerous spores suggesting *Bacillus larvæ*, the identity of which is further confirmed by the fact that they fail to grow on the ordinary media of the laboratory. The odor is definite and characteristic for American foulbrood but, as is sometimes also the case where American foulbrood occurs alone, not pronounced.

The presence of European foulbrood is exhibited by many larvæ of grey, yellow, and brown coloration, lying at the bottom of the cell, and presenting the melting appearance often noted in larvæ affected with this disease. These larvæ showed, on microscopical examination, *Bacillus pluton* in large number. Spores of *Bacillus alvei* were also found in large number in some of these larvæ.

No larvæ in the ropy stage of American foulbrood were found—only the dry adherent scales, while fresh, moist, melting larvæ of European foulbrood were present, indicating an active condition of the last mentioned disease. If the sample is representative of all of the affected larvæ in the colony, it seems probable that American foulbrood attacked the colony first; the scales may have been in the comb since last year or even longer. However, the priority of either disease is a matter of speculation without a complete history of the colony itself.

Mr. Lynch states that several years ago American foulbrood was found about ten miles south of Patterson, and that in the latter part of 1915 the same disease manifested itself near the apiary, from which the sample was taken. European foulbrood, Mr. Lynch further states, broke out very badly about fifteen miles north of Patterson in July 1914 and moved up the San Joaquin river towards Patterson. All who saw this outbreak made a gross diagnosis of both diseases; viz—American foulbrood and European foulbrood. This history relative to the appearance of these two diseases in the vicinity, from which the sample was taken, is interesting as showing clearly that American foulbrood was first in evidence, according to gross or field diagnosis. This is no evidence, however, that American foulbrood was the first disease to make its appearance in the colony from which sample No. 4982 was taken, but it seems not unlikely.

Beekeepers have from time to time sent in samples with the report that both diseases were present in the same comb but they have all proven on laboratory examination to be one or the other disease alone.

So far as the writer is aware, this is only the second authentic report confirmed by laboratory findings of the presence of these two diseases in the same comb.

Arthur H. McCray, M.D.,
Apicultural Assistant, Bureau of Entomology.

JOURNAL OF ECONOMIC ENTOMOLOGY

OFFICIAL ORGAN AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

JUNE, 1916

The editors will thankfully receive news items and other matter likely to be of interest to subscribers. Papers will be published, so far as possible, in the order of reception. All extended contributions, at least, should be in the hands of the editor the first of the month preceding publication. Contributors are requested to supply electrotypes for the larger illustrations so far as possible. Photo-engraving, may be obtained by authors at cost. The receipt of all papers will be acknowledged.—Eds.

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This issue, with two detailed studies of the bionomics of *Musca domestica*, may well be characterized as our house-fly number. It is hardly to be expected that the matter relating to this insect will be accepted without question and if a vigorous skepticism is aroused and others are spurred on to solve problems of practical importance in control work, so much the better. There is no question but that more attention should be paid to the chemotropic and phototropic reactions of both adults and larvæ since limitations along these lines suggest some of the most promising methods for the control work of the future.

The hibernation of this insect, especially under conditions obtaining in the northern United States, is another matter worthy of careful investigation, and it is surprising that the method or methods of wintering have not been carefully worked out in several representative localities, since the common belief that the insect hibernated as an adult has been questioned for several years.

There appears in this issue a brief record of untoward results following the use of a comparatively untried insecticide. The autopsy disclosed unsuspected pathological conditions which were responsible for the death of the animal. It is only another case emphasizing the desirability of exhaustive tests before there are unqualified recommendations, and the incident itself suggests the ease with which totally erroneus conclusions may be drawn.

Reviews

Ticks, a Monograph of the Ixodoidea, by G. H. F. Nuttall, C. Warburton, W. F. Cooper, and L. E. Robinson. Cambridge University Press, Part III, pages XIII+349–550. October, 1915.

This third part of the monograph of the ticks is under the authorship of Doctor Nuttall and Professor Warburton and deals with the genus Hæmaphysalis. As a companion fascicle has appeared Part II, of the bibliography of ticks by G. H. F. Nuttall and L. E. Robinson, containing a total of 462 titles. Part I of the monograph (Argasidæ) was published in 1908 and Part II (Ixodidæ) in 1911. The same general plan of treatment is followed as in the numbers already issued, and the present part is up to the high standard set by the portions of the work already in print. This number is well illustrated, containing six plates and 144 text figures. The plates are reproduced from former illustrations of the authors. One-half of the text figures are new. The authors recognize forty-two species and eight varieties in this genus. No new species are included, but a number of those rather poorly described previously are more fully characterized, and a considerable number of larvæ and nymphs are described for the first time.

The genus Hæmaphysalis is one of comparatively small economic importance; however, we find by going over the host lists as presented by the authors that nineteen species and three varieties have been found upon domestic animals, and four species have been taken on poultry. Two species of this genus have been proved to carry disease. One of these, *H. leachi*, acts as the chief vector of *Piroplasma canis* which produces a very fatal disease of dogs in Africa, known as malignant jaundice. The other, *H. cinnabarina* var. *punctata*, has been shown to be capable of transmitting British redwater, the causative organism of which is known as *P. divergens*. The part played by this tick in transmitting this disease is probably a minor one, as *Ixodes ricinus* has been shown to be the principal carrier. It is interesting to note in this connection that the authors consider *H. chordeilis* (Packard 1869) to be identical with Koch's *H. cinnabarina* described from Brazil, thus suppressing a name which is familiar to American workers in this group. They have also concluded that the above mentioned form (*punctata*) is merely a variety of *H. cinnabarina*.

Only two species of the genus occur in the United States, these being *H. cinnabarina* (*H. chordeilis*), and *H. leporis-palustris*, the common rabbit tick. The former of these species, together with its European variety *punctata*, is the most widely distributed tick of the genus. A valuable list showing the distribution and hosts of the various species of the genus is given, and a good summary of what is known of the biologies of species of this genus is included. The life-histories of six species have been more or less completely worked out. The authors add some new biological records to those already published by themselves and various other workers, and unpublished notes by Doctor Brumpt of Paris on *H. concinna* and *H. inermis* are included. The latter species exhibits certain biological traits unique among the ixodid ticks. The female deposits comparatively few eggs (about 200), and the time required for larvæ and nymphs to engorge is exceptionally short, ranging from one and one-half to three hours in the former and one to two hours in the latter.

The fact is significant that only fourteen out of the total of fifty species and varieties recognized by the authors are known in all four of their stages. Further, it may be mentioned that but nineteen species and varieties are known in the nymphal stage and fourteen in the larval stage, and but one sex has been discovered in thirteen of the species and varieties.

The authors are to be congratulated on the fact that they have produced the present commendable fascicle under such trying conditions and that they are proceeding with the other parts of the monograph as rapidly as possible. It is hoped that American investigators will assist in this valuable work as far as possible by purchasing parts of the monograph already issued, since it is understood the expense of publication is now, in part at least, falling upon the authors.

F. C. Bishopp.

April 1, 1916.

Reports on Scale Insects, by J. H. Comstock. Cornell University, Bulletin 372, p. 603. 1916.

This is a reprint of the epoch-making papers on the Coccidæ published originally in the reports of the Entomologist of the United States Department of Agriculture and in the Second Report of the Cornell University Agricultural Experiment Station. These contributions to knowledge are so well known that a review is unnecessary. They are indispensible to any student working on the Coccidæ and it is by all means desirable that they should be in a readily available form. The publication also serves to emphasize the practical value and importance of one of the earlier contributions by a beloved teacher and investigator in both economic and systematic entomology (*Advertisement*).

Typical Flies, a Photographic Atlas of Diptera, Including Aphaniptera, by E. K. Pearce. Cambridge University Press, p. 1–48. 1915.

This small volume contains over 150 very satisfactory process reproductions of typical flies and is designed to encourage the beginner in the study of a group worthy of much more attention than has been given it by entomologists, though the last few years has witnessed a gratifying increase in dipterological studies. Each figure is accompanied by more than the usual elucidatory matter and there is an excellent index. The volume, a very good substitute for a small collection of representative species, may be procured through G. P. Putnam's Sons for $1.50 (*Advertisement*).

Minnesota State Entomologists' Reports, Index, by O. J. Wenzel. Circular No. 38, p. 1–40. 1916.

This detailed index, preceded by a list of the reports and bulletins and with an appendix listing the other publications of the State Entomologist and the Division of Entomology, University of Minnesota, will greatly facilitate reference to this excellent series of publications begun over twenty years ago by Otto Lugger and continued in a highly successful manner by the present incumbent. Entomologists may obtain this circular on application (*Advertisement*).

Current Notes

Conducted by the Associate Editor

Mr. J. P. Ivy is the State Apiary Inspector of Arizona.

Mr. D. L. Van Dine, Bureau of Entomology, has gone to Mound, La., to resume his work on malaria mosquitoes.

Mr. F. C. Bishopp, Bureau of Entomology, who underwent a surgical operation in February, is now on active duty.

Dr. C. Gordon Hewitt, Dominion Entomologist, of Ottawa, Canada, visited the Bureau of Entomology on March 16.

Dr. E. F. Phillips, of the Bureau of Entomology, addressed the New York Farmers on April 4 at their annual dinner in New York City.

Dr. Back, Bureau of Entomology, has returned to Washington and is engaged in writing up his general report on the Mediterranean fruit-fly.

The death of Thomas H. Cunningham, Inspector of Fruit Pests for British Columbia, occured February 16th. (*Canadian Entomologist*).

Dr. L. O. Howard has recently been elected a member of the National Academy of Sciences and President of the Washington Academy of Sciences.

Mr. Geoffrey Meade-Waldo, the author of many papers on the Hymenoptera, and for some time connected with the British Museum, died March 11.

Mr. George S. Demuth, Bureau of Entomology, attended the meeting of the Pennsylvania State Bee-Keepers' Association at Lancaster on March 3–4.

Mr. C. Joseph Manter of California has been appointed field assistant of the Bureau of Entomology for work in that state on sugar-beet and truck-crop insects.

Mr. Harold L. Weatherby of Alabama has been appointed field assistant in the Bureau of Entomology, for work at Rocky Ford, Colo., where he was employed a few years ago.

Mr. B. R. Leach, Bureau of Entomology, has returned to his permanent headquarters at Winchester, Va., where he will continue his investigations of the woolly apple aphis.

Messrs. G. H. Cowan and M. S. Stanley have been appointed temporary field assistants, Bureau of Entomology, in connection with the work on the Rocky Mountain spotted-fever tick.

Mr. A. J. Ackermann, Bureau of Entomology, has been in Washington for a few weeks preparing his notes on the subject of nursery insects, and has now returned to his headquarters at West Chester, Pa.

Mr. H. B. Scammell, Bureau of Entomology, in charge of the laboratory at Brown Mills, N. J., spent a few days in Washington and has now returned to his headquarters to resume his studies of cranberry insects.

Mr. J. G. Hester, Bureau of Entomology, who assisted Mr. M. M. High in his work on onion insects and truck-crop pests last year, has been reappointed and will resume work at Brownsville, Texas, and vicinity.

Mr. W. F. Fiske, who has been in British East Africa for some time in the investigation of the bionomics of Tsetse flies for the Imperial Bureau of Entomology, has returned to England by way of Khartum and Cairo.

Mr. E. H. Siegler, Bureau of Entomology, who has been in Washington for the past few months, has now returned to his field headquarters at Grand Junction, Colo., where he is engaged in codling moth investigations.

Dr. E. D. Ball has resigned as Director of the Utah Agricultural Experiment Station, and hopes to soon take up entomological work again. Unless a good opening occurs, he will probably spend a year in graduate study.

Mr. W. V. King, Bureau of Entomology, is now at Florence, Mont., where he will have charge of the Bureau's work on the eradication of the spotted-fever tick. He will return to Louisiana sometime during the summer.

Mr. Charles E. Smith, Bureau of Entomology, who has had experience in investigation of insects injurious to truck crops at Baton Rouge, La., has been reappointed to assist Thomas H. Jones at the Baton Rouge station.

Mr. C. F. Turner, Bureau of Entomology, who has been stationed temporarily at Hagerstown, Md., for the purpose of conducting some histological and biological studies, will shortly return to his field station at Greenwood, Miss.

The field station formerly conducted by the branch of Cereal and Forage Insect Investigations, Bureau of Entomology, at Nashville, Tenn., has been moved to Knoxville. The post office address is R. F. D. No. 9, Knoxville, Tenn.

Mr. E. W. Geyer, Bureau of Entomology, formerly in charge of the laboratory at Roswell, N. M., has severed his connection with the Bureau and Mr. R. J. Fiske is now in charge of this laboratory and is engaged in codling moth investigations.

Mr. P. R. Myers, of the Hagerstown, Md., laboratory, Bureau of Entomology, recently visited Washington for the purpose of consulting the collections of the U. S. National Museum in connection with investigations of the parasites of the Hessian fly.

Mr. W. F. Turner, who has been assisting Mr. A. C. Baker at Vienna, Va., in life-history studies of plant lice, resigned from the Bureau of Entomology to accept appointment with the Georgia State Entomologist, with headquarters at Thomasville, Ga.

Mr. H. K. Plank, Bureau of Entomology, who has been assisting Mr. Scammell in cranberry insect investigations in New Jersey, has been transferred to the laboratory at Grand Junction, Colo., where he will assist Mr. Siegler in codling moth investigations.

The Secretary for Agriculture and Industries of British Columbia has issued a regulation under date of March 23, 1916, requiring that all bees entering the province be accompanied by a certificate vouching for their freedom from infectious brood diseases.

Mr. D. Isely, Bureau of Entomology, who has been in Washington preparing his notes on grape-insect investigations, has returned to the field for the purpose of resuming investigations of the grape-berry moth and other grape insects at North East, Pa.

In Palmer Park and North Cheyenne Canyon, within a short distance of Colorado Springs, Colo., Mr. George Hofer, Bureau of Entomology, will make a study of *Agrilus acutipennis* var., in relation to the dying of oak trees within the City and Mountain Parks.

Mr. H. Yuasa, a graduate student and graduate assistant in the Department of Entomology, Kansas State Agricultural College, will continue his graduate work in the Department of Entomology of the University of Illinois, where he has received a graduate scholarship.

The "green bug" outlook for Texas, Oklahoma and Kansas is considerably improved over the conditions of last fall. However, there is still a possibility of a serious infestation of this insect during the coming spring, providing meteorological conditions prove favorable.

Mr. T. H. Parks, formerly extension entomologist of Idaho, and for several years entomological assistant in the Bureau of Entomology, has been appointed extension entomologist of the Kansas State Agricultural College. Mr. Parks began his work in Kansas the middle of March.

Mr. A. C. Baker, Bureau of Entomology, who has been engaged in life-history studies of plant lice, with headquarters at Vienna, Va., has been transferred to Washington, D. C., as permanent headquarters, where he will continue life-history studies of plant lice and systematic work with Aphididæ.

According to *Science*, Dr. L. O. Howard, Chief of the Bureau of Entomology, Washington, D. C., and Professor Antonio Berlese of Rome, have been elected honorary fellows of the Entomological Society of London, to fill vacancies caused by the deaths of J. H. Fabre and Brunner von Wattenwyl.

Mr. R. B. Ellis, who has studied entomology at the Agricultural College at Manhattan, Kan., has been engaged by the Bureau of Entomology, to assist in work on insects injurious to sugar beets and truck crops at Wichita, Kan., where Mr. F. B. Milliken is in charge of the local station.

Mr. B. L. Boyden, Bureau of Entomology, who has been engaged in experimental work on the sugar-beet wireworms and other insects injurious to sugar beet, beans, and other truck crops at Oxnard, Cal., has taken permanent headquarters at Pasadena, Cal., the Oxnard station remaining as a substation.

Mr. George S. Demuth, Bureau of Entomology, will leave soon for Winchester, Va., to resume the work on the effect on bees of spraying fruit trees, in coöperation with the Office of Deciduous Fruit Insect Investigations. The work will also probably be continued at a more northern point at a later date.

Mr. S. L. Mason has been appointed as scientific assistant in the Bureau of Entomology and detailed to assist Mr. John J. Davis at the West Lafayette, Ind., field station. Mr. Mason takes the place of Mr. Daniel G. Tower, who has been transferred to the Tropical and Subtropical Fruit Insect Investigations.

Mr. E. B. Blakeslee, Bureau of Entomology, who has been in Washington preparing notes on the subject of his field investigations, has returned to the field to resume his investigations of peach insects and will spend a good deal of his time this season in the neighborhood of Springfield, W. Va., investigating the peach-tree borer.

Mr. W. W. Yothers, Bureau of Entomology, is about to take up a new phase of the citrus insect problem of Florida, namely, a study of the insects and insect control in relation to the extensive culture of limes on the Florida Keys. Mr. Yothers has been requested to submit a detailed project plan of this work for approval.

The field station of the Bureau of Entomology at Batesburg, S. C., which has been in operation for several years, has been discontinued. Mr. E. A. McGregor, who was in charge, has been detailed to work on cotton insects in the Imperial Valley of California. Mr. F. L. McDonough is now stationed at Quincy, Fla., on work with tobacco insects.

Information has been received from Mr. M. M. High, Brownsville, Texas, and from Prof. F. W. Mally, County Agent, Laredo, Texas, that a considerable acreage of onions and garlic have been saved from the ravages of the onion thrips by the control measures advised by the Bureau of Entomology at Mission, Mercedes, Harlingen, Laredo and Brownsville.

Mr. George F. Moznette, formerly instructor, has been appointed Assistant Professor in Entomology at the Oregon Agricultural College and Station, and began his duties March 1. Mr. Moznette has just completed a year's advanced work in Entomology at the University of California at Berkeley and will be engaged in research problems at the Oregon Station.

Mr. J. R. Horton, Bureau of Entomology, has closed up his station at New Orleans and has left for Southern California to study the Argentine ant as affected by Pacific Coast conditions. He will do this work in coöperation with Mr. Woglum at the Pasadena Station. The California end of this investigation will probably be completed within two or three months.

At the Southern Rocky Mountain Station, Bureau of Entomology, Colorado Springs, Colo., a camp was established on March 7 on the east slope of Pike's Peak, at an altitude of 9,500 feet. From this station special studies will be made by Mr. J. H. Pollock on the "Relation of Altitude to the Periodical Phenomena of Insects," along with other special and general projects.

Mr. H. G. Ingerson, Bureau of Entomology, who has been assisting Mr. Simanton at Benton Harbor, Mich., in connection with orchard-insecticide and spraying-machinery investigations, after spending some little time in Washington in the preparation of his field notes, has now returned to the field for the purpose of undertaking investigations of the grape-berry moth and other grape insects in northern Ohio.

Mr. N. F. Howard, Bureau of Entomology, who was engaged during the past summer in work on the root-maggots and other insects injurious to onion and cruciferous crops at Green Bay, Wis., and who has been studying for a Master's and Doctor's degree at the Ohio State University, has been engaged to continue the work begun at that Station, and also to investigate insects as carriers of pickle diseases.

As a result of experiments carried on by the branch of Cereal and Forest Insect Investigations, Bureau of Entomology, during the past winter, it has been determined that *Laphygma frugiperda* S & A. wintered over in the pupal and larval stages as far north as northern Florida and central Texas but failed to do so in Oklahoma. The results in wintering-over experiments have not yet been secured for Kansas, Georgia and South Carolina.

Dr. W. M. Wheeler of the Bussey Institution, in attendance at the meeting of the National Academy at Washington, April 17–19, spent part of a day in the U. S. National Museum studying the collection of ants left by the late Theo. Pergande. Mr. Pergande's entire collection has been given to the Museum by his daughter. The ants are in good condition, but many of the insects of the other orders have been uncared for in late years and badly eaten by Dermestids.

A new and important project of the Bureau of Entomology for the coming year will be an investigation in coöperation with the Bureau of Plant Industry of insects as carriers of mosaic and other diseases of cucumbers and other cucurbits with special reference to the pickle industry of the states of Wisconsin, Michigan and Indiana.

The principal insects which act as disseminators of these diseases are the striped and twelve-spotted cucumber beetles and the tarnished plant-bug, while other insects are under suspicion.

In Waldo Canyon, within the Pike National Forest, Colorado, at an altitude of 7,500 feet, an outdoor cage will be constructed surrounding and covering the main trunk of a 20-inch diameter yellow pine tree, infested by *Dendroctonus ponderosæ* Hopk. The butt cut will be left intact and other sections stood up within the cage. A study will be made by Messrs. W. D. Edmonston and George Hofer, Bureau of Entomology, of the flight habits of this important tree destroyer. Other infested trees in close proximity will also be utilized for study.

The fig moth (*Ephestia cautella* Walk.) has been reported to the Bureau of Entomology by Mr. M. M. High as occurring in new material. Moths have been reared from Kafir corn and cowpeas, and also in alfalfa meal. This species has been treated in detail in Bulletin 104, a list of food plants being given on page 19. It is one of the several species of insects which have been found injuring cork in the heads of pop bottles. We have also received specimens through the Federal Horticultural Board occurring in yeheb nuts from Arabia.

The broad-bean weevil, *Laria rufimana* Boh. (Bulletin 96, Part V, Bureau of Entomology), has recently been ascertained to have a positive alternate food plant in the garden pea. Numerous specimens were obtained in peas from Paris, France. Thus far we have not received notice of this insect occurring in peas on the Pacific Coast and agents of the Bureau and correspondents in California are urgently requested to keep a lookout for it. The discovery of this new food plant will probably render it impossible to stamp out the pest in the few regions where broad or Windsor beans are grown, and which it is now known to infest.

During the month it transpired that the British Steamship *Appam*, brought to Norfolk, Va., as a German prize of war, had about two hundred tons of cotton seed from West Africa as a part of its cargo. Messrs. Marlatt and Hunter of the Federal Horticultural Board visited Norfolk and Newport News in connection with the disposition of this seed, which was found to be infested by the pink bollworm, *Gelechia gossypiella*. A provisional sale of the seed by the Admiralty Court to an oil-mill in North Carolina was set aside when the danger was explained. Arrangements were immediately made for placing the entire lot in sulphuric-acid vats as a preliminary to the conversion of the seed into fertilizer. As an additional precaution the holds of the *Appam* were fumigated with hydrocyanic-acid gas under the supervision of Mr. Morrison.

The following changes in titles, rendering the designations of the heads of offices more compatible with their specialized lines of work, are herewith announced:

C. L. Marlatt, Entomologist and Assistant Chief of Bureau.

W. D. Hunter, Entomologist in Charge Southern Field Crop Insect Investigations.

A. L. Quaintance, Entomologist in Charge Deciduous Fruit Insect Investigations.

F. H. Chittenden, Entomologist in Charge Truck Crop and Stored Product Insect Investigations.

A. F. Burgess, Entomologist in Charge Preventing Spread of Moths.

E. F. Phillips, Apiculturist.

L. H. Worthley, Agent, Preventing Spread of Moths.

G. F. White, Expert, Apicultural Investigations.

E. A. Back, Entomologist, Mediterranean and Other Fruit-Fly Investigations.

W. D. Pierce, Entomologist, Southern Field Crop Insect Investigations.
N. E. McIndoo, Insect Physiologist, Deciduous Fruit Insect Investigations.
A. T. Speare, Myco-entomologist, Deciduous Fruit Insect Investigations.

It will be of interest to entomologists to know that the cotton fumigating plants in Boston, constructed by the Bureau of Entomology, are now in active operation. Over 1,200 bales of cotton have already been fumigated in the two plants now available. These plants, furthermore, are being rapidly enlarged so that ultimately their capacity will be approximately 1,000 bales a day each. It is very satisfactory to know that these plants are in successful operation, inasmuch as this large-scale work has been hitherto on a somewhat theoretical basis. As previously noted, this work represents the largest insect fumigating plants which the world has ever seen, and undoubtedly very much the largest investment ever made for this purpose. It is reported that the fumigation plant at Oakland, Cal., to meet the needs of the port of San Francisco, is again in readiness. In common with one of the plants in Boston, this Oakland plant had a breakdown, not having originally been made strong enough to stand the vacuum pressure. A similar plant is in process of construction at Newark, N. J., and probably before long there will be a plant of the same kind available in New York City. Plants at other ports are also being contemplated. These are all private concerns, and make a regular charge for disinfection.

S. A. Rohwer, of the Bureau of Entomology, has recently designed and had constructed a small cage to be used to confine, under natural conditions, growing plants. This cage is a bronze wire cylinder, the top of which is closed by a lid which fits on like the lid of an ash can; the lower end is open and fits against the soil. The frame is made of galvanized iron. The top and bottom are bands two inches wide, with the edges turned, and are held apart by three strips of one inch by one-eighth inch galvanized iron which project six inches below the bottom of the cage so they can be driven into the ground to hold the cage in place. The uprights are soldered to the bands on the inside. The bronze wire is held in place by solder. The lid is a galvanized iron band over the top of which is bronze wire. The cage is eighteen high by fourteen inches in diameter. On one side is soldered a one and one-half inch screw top which affords an easy way of introducing insects after the cage is in place. This cage is very useful in experiments on insects working on living plants, as it is possible to grow, under nearly natural conditions, clean host plants and to infest them with known insects. At the Eastern Field Station it is known as the G type cage and is used in studies on insects of the genus *Evetria* and its parasites. More information concerning its construction or cost may be had through correspondence.

Annual Meeting of Pacific Slope Branch of American Association of Economic Entomologists

The annual meeting of the Pacific Slope Branch of the American Association of Economic Entomologists will be held in connection with the meetings of the Pacific Slope Division of The American Association for the Advancement of Science at San Diego, Cal., August 9-11, 1916.

It is hoped that there will be a large gatheringand that all entomologists on the Pacific slope will attend. It is especially desired that entomologists in other parts of the country who anticipate visiting California will arrange their trips so as to be present at this meeting. Further details in regard to the meeting and information concerning the program can be secured by addressing the secretary, Professor E. O. Essig, University of California, Berkeley, Cal.

Mailed June 24, 1916